FARM LOAN DEMAND ELASTICITIES AND THE RELATIONSHIP BETWEEN THE FARM CREDIT SYSTEM AND COMMERICAL BANK LENDING

A Thesis

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ABSTRACT

This study aims to investigate the availability of credit and its cost to US agriculture.

A dynamic dual cost function is employed to investigate and compute credit demand elasticities for operating and term credit and their relationship with the demand of other inputs. This allows for the analysis and interpretation of the input elasticities, specifically the interest rate elasticities. These elasticities are then incorporated into the model that aims to test the effectiveness of the counter cyclical lending role of the Farm Credit System (FCS) relative to the Commercial Banking (CB) system in the US over the past 80 years.

We estimate demand elasticities for each of the five cornbelt states including Illinois, Indiana, Iowa, Missouri, and Ohio as well as their aggregate average and find that credit demand elasticities are nearly elastic, for both operating and term credit. This implies that farmers are sensitive to changes in interest rates. This sensitivity is observed in the cross elasticities measures of variable and quasi-fixed assets including farm land.

We also investigate the demand/supply relationship between FCS loans and those of the CB sector. We incorporate the interest expense elasticities described above to show how farmers sensitivity to interest rates affects farm lending. We find that in periods during which elasticity is rising, the quantity of FCS loans increases relative to the commercial sector. We find other evidence of counter cyclical demand between the two sectors including periods of economic distress (GDP falls) which see an increase in FCS loans, and a rise in treasury yields which favors commercial banks.

BIOGRAPHICAL SKETCH

Amy Carduner was born October 20, 1992 in Swift Current, SK, Canada. She graduated from the University of Saskatchewan in May 2014 with a Bachelors of Science in Agricultural Economics. She is a Master of Science candidate in Applied Economics and Management at Cornell University, and has accepted a position as a Financial Representative at Farm Credit Canada.

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CHAPTER I

INTRODUCTION

1.1 Background

Agriculture is an ever evolving industry in the United States (US) and has become heavily capital-intensive over the past 100 years. This dependency on technology has caused an increase in the demand for debt financing and farmers, generally speaking, cannot raise equity and are consistently limited by the access to credit in order to grow and sustain their business. The dependency on loans, coupled with the exposure and sensitivity to macro-economic downturns, means that many farms across the US are at the mercy of their credit providers to grow, or even continue their business. However, the characteristics of credit demand for US farmers has not been studied in detail, even though there is a significant body of literature that leads to a good understanding of the agriculture finance market place, and the effect of credit on farmers' decision making. In financial economics, the relationship between credit demand and interest rates, specifically, the credit demand elasticities are described at the micro level. At the macro level lies the institutions that provide credit. In the US there are both private and public institutions for agriculture credit and how they compete, what their roles are, and how each responds to changes in demand (i.e. change in elasticity) is an important economic problem. The historical relationship between public and private lending institutions is, after 100 years, poorly understood. For example, what might be the most influential factor in the success of agriculture, is the component that cannot be predicted or influenced: weather. As the prospect of obtaining new loans at a manageable interest rate is contingent on the weather's cooperation, this became a perilous cycle in the early 20th century. When the weather allowed for a successful growing season, famers were able to pay off loans in a timely fashion and the positive dynamic between farmers and lenders could continue. However, if in that year, farmers experienced unfortunate weather events such as drought or flooding, the output would decrease, and the ability to pay off the loans would be more difficult. This issue became the main problem in the early 20th century when commercial banking (CB) was the only source of credit for farmers. This volatility in the supply of credit meant that a change was required to continue the growth and prosperity of the agricultural industry. Thus, the Farm Credit System (FCS) in the US was introduced as a counter cyclical lender; to provide credit when farms needed it most.

Despite the appeal of the FCS from a producer stand point, there has been doubt from parties across the US on the effectiveness it has provided and its fundamental role in present day. The American Bankers Association (ABA), which represents commercial banks, has even made the statement to call for a referendum to remove the FCS from legislation and open the market to commercial lending, *…"from the ABA's view, the hope is to get a congressional oversight hearing scheduled so that both lawmakers and the public can start to dig deeper and present a full view of the FCS' business practices. From there, the ABA would push for the FCS to scale back and focus on its core mission. Or, failing that, it would like to see agriculture banks — there are hundreds of banks focused primarily on farm country, he said — be granted tax advantages similar to the FCS. Or, of course, the FCS could give up its tax breaks. These latter moves, he said, would at least level the playing field."* (President of American Bankers Association, August 2015).

Another impediment for agricultural credit, as Baker (1968) points out, is the cost of capital including with credit. He shows in his research that by omitting credit and its costs in the production function, creates econometric bias. Farmers use credit predominately for the purchase of new inputs, meaning if credit is constrained, either by supply or cost, the growth and success of the farm is in jeopardy. Thus, despite credit elasticities being frequently left out of the previous literature, this thesis aims to fill this information gap. Specifically, this research works to understand the relationship of credit in the production system, both from a term and operating stand point, as well as examining how the availability of credit through a tenuous economic relationship between public (FCS) and private (commercial) lending has helped the stability of farm credit in the USA.

1.2 Research Problem

This thesis aims to fill the informational gap surrounding interest rate elasticities in agriculture. Turvey, Bogan, and Salazar explain this gap in the related literature by noting the varying results in the analysis of agricultural credit elasticities. To summarize, in the absence of robust evidence on interest rate sensitivities, policy-makers and Microfinance Institutions (MFIs) are making broad generalizations regarding the demand sensitivity for interest rates in agriculture. As shown in Table 1.1 the results for each study have varying results.

Table 1.1: Elasticity of Demand for Microcredit

Author(s)	Country Studied	Credit Market	Data Collection Method	Results
Weersink et al. (1994)	US	Rural Farmers	USDA survey data	Elasticity estimates between -0.84 and -0.69
Bell et al. (1997)	Punjab	Rural Farmers	World Bank survey data	Elasticity estimate of -0.22
Kochar (1997)	Indian	Rural Farmers	Govt of India survey data	Low demand for credit. Credit demand inelastic
Gross and Souleles (2002)	US	Credit Card Holders	Bankcard issuer acct archives	Short-run elasticity estimate of -0.80
Dehejia et al. (2012)	Bangladesh	Micro-entrepreneurs	Credit co-operative data	Elasticity estimates between -1.04 and --0.73
Karlan and Zinman (2008)	South Africa	Working Poor	RCT with loan contract data	Elasticity estimates between -0.51 and -0.14
Karlan and Zinman (2010)	South Africa	Working Poor	RCT with loan contract data	-
Turvey et al. (2012)	China	Rural Farmers	Field Survey	Average elasticity estimate of -0.60

Source: (Bogan, Turvey, Salazar ,2015)

Karlan and Zinman (2008) suggest that it is assumed the poor are insensitive to increases in interest rates which follows the results found by Bell et al. (1997) and Kochar (1997). Both of these studies, looking at rural farmers in Punjab and India, found that there was relatively inelastic demand estimates. However, these results are contradicted by the work of Dehejia et al. (2012) which showed that the rural farmers were in fact, sensitive to the interest rates and had elastic demand. Despite the research summarized above, there is still an informational gap in the literature as these studies have varying results.

Thus, the primary aim of this research is to determine the demand relationships for short-term and long-term credit and their respective interest rates in the production process for US agriculture in the US. By including these interest expenses into the production function and using the duality processes described in following chapters, the elasticities of the inputs will be determined. While determining the credit demand elasticities is of interest generally, it is as important to understand how static, or changing, credit demand elasticities affect market demand and supply, and even more specifically whether they have differential impacts on the cumulative and marginal loan portions of FCS and the CB sector. Consequently, this thesis aims to assess the effectiveness of the FCS and the Farm Service Agency (FSA) which is directed more at emergency credit and assistance programs, since inception, by incorporating control variables for macroeconomic conditions, as well as the elasticities for interest rates and land expense from the above model to show the sensitivity of the industry to changes in the cost of capital.

1.3 Purpose and Objectives

The overall the purpose of this thesis is to estimate credit demand elasticities and their relationship between Commercial and Farm Credit System lending. We achieve this by following and completing the following objectives:

1) Determine and identify the relationship between interest rates and long and short-term credit demand;

Justification: in order to achieve this objective, we develop several models assuming separability of the inputs. These models include: a static model which assumes that each of the inputs adjust completely to their optimal value in each time period, a partial static model that assumes some of the inputs adjust in each time period and some inputs are quasi-fixed, and a dynamic model which is a less restrictive version of the Static model as it allows for different adjustment rates for various inputs. These models are estimated for each of the five cornbelt states as well as an average of the five. In all models, we include both production inputs, such as fertilizer and seed, as well as intangible inputs (short and long-term credit). By including these inputs into the production function, we aim to examine the relationship between credit and interest rates for agriculture in the US cornbelt states over time.

2) To develop measures for the interest rate elasticity in a production function from duality principles;

Justification: By using both the price elasticities, and Allen elasticities of substitution for each of the models, the measures of input price sensitivity across the cornbelt states can be evaluated. These elasticities are calculated from the three models described in Objective 1. The Dynamic elasticities are also broken into long-run and short-run values, where the short-run elasticities are interpreted as the first period response of factor demands to changes in factor prices. We hypothesize that the short-term interest rate elasticity will be more sensitive in relation to the variable inputs, and the long-term interest rate will be more sensitive for the capital inputs. This hypothesis is due to the nature of the credit terms for short and long-term interest costs. Once the elasticities for the short-run Dynamic model are found they will be incorporated into the following model as described below[1].

[1] This thesis uses the econometric models and specifications from Vanden Dungen and Weersink et al. to estimate the demand for credit as well as developing the elasticities for inputs as described in objectives 1 and 2.

3) To investigate the differential roles that the Farm Credit System and Commercial Banking sectors have on the supply and demand of agricultural credit in the US;

Justification: In order to identify and evaluate the changes in relative lending between the Farm Credit System and the Commercial Banking system, a Seemingly Unrelated Regression estimation is created that uses both macroeconomic variables as well as selected elasticities from the Dynamic model described in above objective two. From this model, we interpret the performance and success of the Farm Credit System in counter cyclicallending, which has been under scrutiny from the American Banking Association (ABA) in recent years. In order to be complete we also observe the value of loans, the share of loans, and the change in loans by the Farm Credit System, the Farm Service Agency (FSA), and the Commercial Banking system.

1.4 Overview of Analytic Framework

The duality portion of this thesis is analyzed using state level data from the five cornbelt states: Illinois, Indiana, Iowa, Missouri, and Ohio, as well as an aggregate average. These states were chosen due to the relative homogeneity of their climate and agricultural practices, which alleviates the problems associated with examining national data across the US. This section of the thesis incorporates a dual cost translog function to estimate the output compensated demand elasticities for the intangible inputs of credit as well as the production inputs. The behaviour of the long-term debt is explored using a partial adjustment or disequilibrium model where the movement of variable to their equilibrium values is approximated by a system of difference equations in a partial adjustment framework. The elasticity measurements are estimated from the resulting system of equations.

In order to test the effectiveness of the FCS, national data from the US is utilized. By incorporating national data into our model which examines the changes in lending between the FCS and the FSA relative to CB, FCS effectiveness can be evaluated for the US. We aim to test the effectiveness of the FCS by comparing the percentage change in relative lending of both the FCS and the FSA to the percentage change in relative lending of the Commercial Banks. To achieve this objective, we use general macro-economic indicative variables (such as GDP and Treasury Yield) as well as the short-run dynamic elasticities for the short term interest, long term interest, and land price elasticities from the dynamic model described above. Although the elasticities are computed using cornbelt data, they are included to show how sensitivity of interest rates affects the lending patterns in agriculture. Thus, in a way that accounts for year-over-year change to the respective FCS (FSA) or CB loan portfolios, we are able to identify their effects on farm lending in the US agricultural sector.

1.5 Thesis Outline

Following this section, Chapter II will outline the related literature of this study as well as a comprehensive outline of the history of both Farm Credit in the US and the FCS and FSA as institutions. Chapter III will present the methods and econometric specification, including a description of duality theory with the advantages and limitations, and the specific methodology for including credit in the production process and the methods to test the effectiveness of the FCS and FSA. Chapter IV will show the explicit descriptions of the equations that will be estimated and the overview of the data included in both portions of the thesis. The results for the Duality portion will be presented and discussed in Chapter V and the results for the FCS effectiveness portion will be analyzed in Chapter VI. Finally, the conclusions and summaries of the thesis will be presented in Chapter VII.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to bring context to this research by examining previous work in this field as well as providing an explanation of the history of the Farm Credit System (FCS) in the US leading up to the present day. By including credit as a component of the production decisions, and showing how we identify the effectiveness of the FCS, this chapter aims to fill in an informational gap missing from the related literature in this field.

To begin, a broad history of the American FCS and agricultural credit in general is presented. This presents the background to the research objectives set out in Chapter I; to estimate the demand for credit in agriculture by including it in the production decisions, identify the interest rate elasticities, and to help to answer the question has the FCS met its mandate as a countercyclical lender over the past 80 years? This discussion will be followed by the rationale to include credit in the production function and decision making. The explanation is based from the research done by Shee and Turvey (2012) in Indian agriculture, however, it sets the stage for this thesis. Finally, the effect of the interest rate for credit is examined more in depth, followed by a mathematical and intuitive explanation for the results that will be presented in Chapters V and VI.

2.2 Agricultural Credit in the US before the Farm Credit System

As Turvey (2015) explains, the story of agricultural finance is a combination of personal initiative, and both direct and indirect involvement by the state, which has led to stable, liquid and secure sources of agricultural credit in the developed world. The agricultural credit discussion began in the United States (US) in 1912, when credit reforms in agriculture had found widespread support in congress looking to manage agricultural credit. Additional to the issue of finding financing for agricultural loans, there were also concerns about the varying interest rates across the US. For example, O'Hara (1983) mentions, interest rates in 1914 that were as low as 5.3% in New Hampshire and as high as 9.7% in New Mexico. Due to these concerns, congress took action in 1916 with the formation of Federal Land Banks, America's first Government Sponsored Enterprises (GSE) (Turvey 2015). However, by the beginning of the 20th century, the U.S. was missing a financial infrastructure to consolidate the national agricultural economy. O'Hara (1983) makes the case that the notion of land banks were not a new concept in the US, showing the variety of guaranteed mortgage companies that did not require paid in capital or reserves and were not supervised. These companies financed agriculture and boom towns, essentially to exploit the investors. However, due to the crop failure of 1884 and the stress of 1893, these companies mostly dissolved.

Historically, Commercial Banks were not permitted to accept and amortize mortgages on farm property until 1913, when the Federal Reserve was established. Due to the structure of operating credit, which could be provided on lien of crops, this type of operational loan was not an issue. Even with the Federal Farm Loan Act of 1916, what was at issue was long-term mortgage credit, commercial banks were given little chance to address the agricultural finance issues.

In order to deal with the many issues surrounding agricultural credit the US, in March of 1913, congress appointed a special commission, often referred to as the American Commission. Its purpose was to investigate and study European experiences with cooperative land mortgage banks, cooperative rural-credit unions, and similar organizations devoted to promote and better agriculture. By the very nature of credit demands, the American Commission took the view that long-term and short-term credit should be segregated. In terms of long-term credit, the commission deliberated the methods to establish a land bank with amortized mortgages under cooperative principles. Additionally, the Commission recommended that any land mortgage bonds be tax exempt to avoid double taxation, as taxation by the state of both the mortgage and the real estate on which the mortgage is secured is a form of double taxation (Turvey 2015). The Commission also noted that in order for each state to produce its own legislation or charter and with each state issuing separate bonds, with different bankruptcy laws, foreclosure rules, conveyances, land taxes, and land titling and registration, any form of land banks should be through Federal charter or law.

The final version of the 1916 Federal Farm Loan Act enacted a state-centric model in favor of a regional model comprised of seven agricultural districts similar to the Federal Reserve Banks. Putnam shows however, that despite the discussions throughout the 1913-1915 period, disagreements arose amongst stakeholders, with one group favoring cooperation, another favoring direct government loans and another favoring private enterprise (Putnam 1919). To '*these seven banks would be overseen by a Federal Farm Loan Board which would be funded by the federal government. Farmers could then apply for loans from the land bank in their particular region as members of a local farm association that could be formed by any 10 or more members. The association would apply for a mortgage through the regional land banks, and the land bank would in turn issue bonds to an equivalent amount, including a 5% capital contribution by the farmer to the association, and a 5% contribution of the association on loans obtained from the Federal Land Banks, Loans could not exceed 50% of appraised land values or 20% of permanent and insured (e.g. barns) improvements, and with amortization not less than 5* *and no more than 40 years, at an initial interest rate of 6% and not exceeding 1% more than the yields on bond issues*' (Palmer 1916, Thomson 1917, Turvey 2015). Due to the specificity of the legislation in stating that mortgages were to be directed to those 'in the cultivation of the land mortgaged,' these same sharecroppers and tenants that had been working the land for years, could finally access credit to buy farmland and become landowners (Turvey 2015).

The Land Banks under the 1916 law and the Intermediate Credit Banks under the 1923 law were established to provide agricultural finance on a sustainable basis. By issuing bonds to investors, the land banks were able to obtain funds, who then would supply the funds to support farm mortgages. In return, and backstopped by a treasury guarantee, the bonds were secured by the first mortgages of the farm being lent to. The Intermediate Credit Banks, that provided production and marketing credit, raised funds through debentures secured by farmer notes, inventories and warehouse receipts. Both of these banks were able to attract good terms on their bonds and debentures, about 1% to 1.5% above treasury bills, and could therefore offer low interest rate loans with changes occurring in tandem with treasury bills (Turvey 2006).

All bonds issued by the Federal Land Banks or Joint-Stock Land Banks were exempt from federal, state, municipal, and local taxation as they were deemed to be instrumentalities of the government of the United States. As anticipated, the main purpose of enacting legislation on farm credit was to provide a means by which farmers with limited resources could access credit on good terms. The problem arose as there were also a population of farmers who could provide security and could therefore obtain loans from Commercial Banks. This system posed some issues as the Commercial Banks would have argued their disadvantage and possible crowding out of the private sector due to the farm credit bonds being issued tax-free, whereas loans from commercial institutions that were derived from taxable savings and certificates of deposits were taxable.

Disputes began to arise around 1917, as the Farm Mortgage Banks Association of America campaigned against the tax-emptions for cooperatives and joint-stock companies as set out in the Farm Act of 1916. Until the Federal Reserve Act in 1913, Commercial Banks could not make loans to farmers, so that insurance companies (using premiums) and farm mortgage brokers (by issuing bonds) were the primary sources of farm credit (O'Hara 1983). Due to these disputes, congress proposed the dual path program, meaning the mortgage broker's ability to establish joint-stock land banks, might appease them. This system began to unravel by 1921 with a bill to repeal tax-free status in 1920 and another in 1921 to eliminate joint-stock land banks entirely. However, as Turvey explains, within the limit set forth, they could behave as a commercial bank, against the spirit of the Act, while claiming tax-exemption for the benefits of private interests (Turvey, 2015).

Another issue that plagued the joint-stock banks were the activities they were engaged in. By 1930-31 the lending of joint-stock banks was in large decline, and this was largely self-inflicted due to the lack of public confidence in the bonds after the joint-stock land banks had gone into receivership. Other banks began noting that their own bonds were selling below par, and used whatever capital they could to repurchase those bonds in order to improve their own conditions rather than issuing new loans. This was intensified by 1933, with the repercussions of the great depression being felt strongly by the banks. The shortfall in liquidity from commercial banks, and also the inability to draw on funds deposited in financial institutions, was forcing many farmers to foreclosure. The hardest hit in this time period were the individual creditors and the joint-stock land banks (Turvey 2015). The Land Bank system became severely stressed during the depression years when low prices coupled with poor production reduced the ability of farmers to pay mortgages.

To finalize and liquidate the Joint-Stock Land Banks, the Emergency Farm Mortgage Act of 1933 prohibited them from issuing tax exempt bonds or from making further mortgages loans except to refinance existing loans. The purpose of this Act was to permit an orderly liquidation of the Joint-Stock Banks, which involved the Federal Land Banks acquiring their mortgages.

The enduring question of whether the Farm Credit System is ultimately socially optimal inspired the second portion of this thesis. As Turvey reviews, O'Hara (1983) raised this question in the context of tax-free bonds generally. She describes the distortion to land prices brought about by the relaxation of credit constraints and indirect subsidy on interest rate, as well as what is perceived as an implicit guarantee by the federal government. She also claimed it was farm mortgages, not other economic factors that drove up land prices between 1917 and 1920-21, and the consequent decrease in land prices were due to the over-valuation caused by mortgaging. New mortgages, including refinancing, fell from $1,773 million to $482 million for a decrease of about 73% between 1921 and 1922. However, as the land prices peaked between 1921 and 1922, the weakening conditions of low prices exhibited a steep decline in farmland prices (Turvey 2015, and O'Hara 1983).

Although the Land Banks of the early 20th century are no longer in operation, the innovations they provided for the FCS today, primarily using the bond markets for agricultural credit, proved to be of great economic benefit for a number of reasons. Firstly, the issuance of bonds against the value of farm real estate, and aggregated across space, provided a safe medium for secondary market investors. Secondly, agricultural land bonds that were secured by real assets and diversified across regions and crops/livestock were of low risk and the lower yield on the bonds were transferred positively to the cost of farm mortgages. Finally, although the bonds were fixed in terms and duration, the farmer could make additional principal payments in order to increase the rate of amortization Turvey 2015).

2.3 The US Farm Credit System

The structure of the present farm credit system is the result of many discussions during the decades leading up to the 1930's and the amendments following the farm financial crisis of the 1980's. Today, it is comprised of Farm Credit Banks, a Bank for Cooperatives (CoBank) and the Agricultural Credit Association. This system is founded in the activities of the Farm Credit Administration and its roots in the cooperative movement; this distinguishes this system from other countries, such as the Canadian Farm Credit Corporation, which was not rooted from a cooperative movement.

During the beginning of the 20th century, the US was battling unprecedented economic growth in both its urban and rural economies, with mass immigration into and within the US. The political fortunes rested with urban development, which as a political base, often usurped the growing needs of rural population (in health, education, transportation, infrastructure, and the adoption of technology and access to credit). This created a dire need to increase the economic efficiency and productivity of farming, as well as a need to improve human interests by making agricultural life more dignified and attractive. Due to the inability of farmers to obtain credit, ownership was limited to those with the ability to acquire land. This left, almost with impunity, a system of tenancy that provided in one hand few rights to tenant farmers and unheeded speculation in land by the owners of capital (Turvey 2006). One of the main goals of this time, was that the strength of rural communities would be built around a population of landowners who rather than being absentee, would live and grow the communities.

The cooperative reform movement was designed to encourage farmers to work together as a community of sorts, to better their economic interests and provide competition to squash the unscrupulous. While the agricultural sector was operated majorly by tenants whose cropping patterns and choices were dictated by the landowner, farms were devoid of any encouragement to diversify beyond that which could be marketed. However shallow the profits be, encouraging systematic risk taking, and leaching the soil is required for sustained husbandry (Turvey 2006).

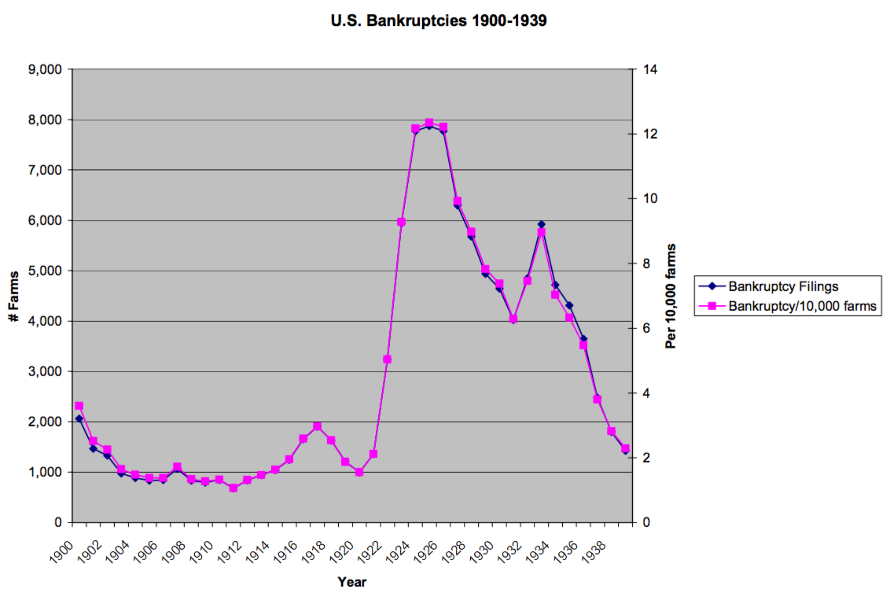
The proposition of the farming cooperative economy system was such that farmers could group together as a buying group to compete with input suppliers, or as a selling group to market crops to the best interest of the members of the group, rather than an uninterested third party. In order to facilitate this system, the role of the state was to facilitate the voluntary emergence of the cooperative or association, not to regulate it. The Commission called for the development of cooperative banks and credit unions to keep money and financial resources in the community rather than urban centers (Turvey 2006).

To initiate the discussions about a Farm Credit Cooperative, Cornell's George Warren raised the idea that the assurance of an adequate supply of credit could be obtained through decentralized cooperative credit associations operating outside of a subsidy regime but within the central sphere of government oversight as limited liability corporations. W.I Myers, another Cornell professor, was the chief architect and governor of the Farm Credit Administration. In 1934 he spoke about a 5% contribution to the FCA, that would allow the farmer to become part owner of the institution with a voice in its management, and ultimately the ownership the financing and control of the Farm Credit System would be entirely in the hands of its owners (Turvey 2006).

Due to the public stress and political activism surrounding the years of the great depression, the unrest began in 1929 and started to rise. In 1932, the Farm Holiday Association, created by the activist Milo Reno, was created. The word 'Holiday' was used specifically as a euphemism for strike. This organization was formed to strike against the low commodity prices and enact some action from the federal government. Reno's request was to receive a fair price, which to him was at least the cost of production.

The low commodity prices were also coupled with the increasing number of farm bankruptcies. As shown in Figure 2.1 (Turvey 2006), the number of bankruptcies was driven up by the post-war depression starting in 1921:

Figure 2.1: US Bankruptcies from 1900-1939



Beginning in 1921, bankruptcies increased to over 3,000 by 1922, 6,000 in 1923, and nearly 8,000 from 1924-1926. Due to the credit rationing by commercial lenders and suppliers, farmers were constrained so much that a more reliable lending regime was needed (Turvey 2006). Due to the technical advances and expanding farm sizes, farmers needed more credit than prior to and including the war years; credit had become paramount to sustainable growth strategies. The structure of credit was a contentious issue in agriculture. For those farmers who did borrow from commercial banks, the rates were high, credit terms were poor, and more often than not even long-standing reputable farmers required a co-signatory.

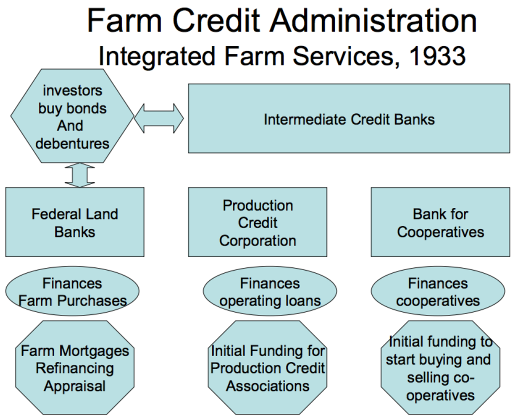
In order to begin combating these issues, congress began working on the Emergency Farm Mortgage Act of 1933. Ultimately, Myers was asked to work on the Act, and the Farm Credit Act of 1933 would eventually establish the Farm Credit Administration (FCA) known today. The essential elements of this Act were to freeze foreclosures until the Act could be fully implemented, that interest on federal land bank loans would be reduced from 5.5% to 4.5% on all new and existing loans, that refinancing of private loans would be done at 4% and with the same terms as Land Bank loans, and that the face value of existing mortgages on inflated land values would have to be adjusted to reflect realistic market conditions (Turvey 2006). As part of the Farm Credit Act, the FCA would issue bonds secured by the value of farm real estate and in order to receive loans from the FCA, Meyers required that all land be appraised to ensure fair value.

The long term goal of the FCA according to Myers in an address to the American Farm Economics Association in 1937 while he was still Governor of the FCA *"is to establish on cooperative principles, a complete coordinated credit system for agriculture, operated on a business basis, farmer owned and controlled, and designed to meet at all times and at the lowest possible cost the sound credit requirements of the farming industry on repayment terms suited to its needs. Stated another way, the credit system we are seeking to establish may be thought of as a farmer-owned cooperative service organization whose function it is to borrow funds, through* *the sale of bonds and debentures, for such periods of time as may be required for the farming industry; and to make loans to individual farmers and farmers' cooperative associations with a basis for credit on terms best suited to their needs at interest rates representing the cost of borrowed funds plus a margin to cover the cost of operation and necessary reserves."* (Myers, 1937 page 83).

Due to the Act, the FCA was established as a permanent production credit system for agriculture and a system for providing credit on a business bases to farmer's cooperatives marketing and purchasing associations. This allowed for a complete system of credit for agriculture that would provide for long term loans to finance the purchase of farms, short term loans for general production, and loans to farmers' cooperative associations (Myers 1934, Turvey 2006).

The Farm Credit Administration had four divisions: The Land Banks and the Intermediate Credit Banks were moved from the department of the treasury to provide the mechanism by which money would be raised for lending while two divisions for production credit and cooperative credit were added. Also, the FCS was divided into 12 regional centers across the US, with each center having a Federal Land Bank, an Intermediate Credit Bank, a Production Credit Corporation, and a Bank for Cooperatives. This system is shown in Figure 2.2 (Turvey 2006) and descriptions of the services are below:

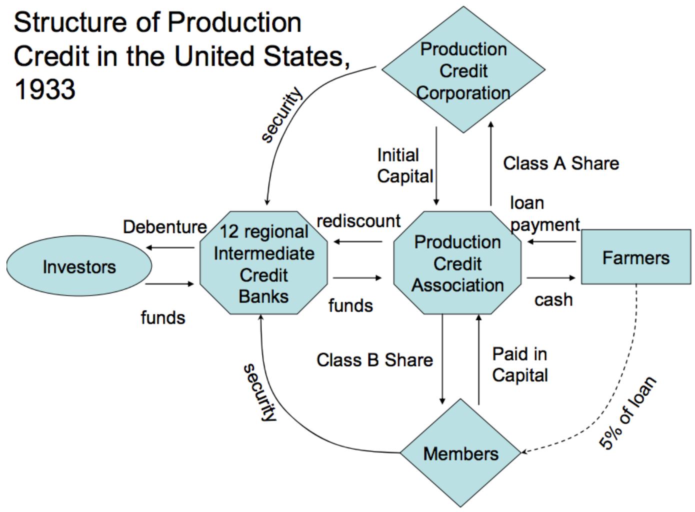
Figure 2.2: The Farm Credit System in 1933



First, the Federal Land Banks direction was to standardize farm mortgages and provide lower interest rates, and from time to time, as in the depression, act as an agent of policy. Secondly, the Bank for Cooperatives was designed to provide working capital loans to cooperatives that buy (commodities etc) from growers or cooperatives that sell (inputs etc.) to growers. Thirdly, the Production Credit Corporations were established as an intervening financing institution for local retail credit institutions called Production Credit Associations (PCAs). The Production Credit Corporations provide the initial startup capital for the PCA. Finally, the PCA provides secured loans of variable duration for general agricultural purposes including the financing of planting, cultivation and harvesting of crops, the breeding and feeding of livestock, the production of milk and other dairy products, the production of poultry and poultry products, and other types of agricultural production (Turvey 2006).

The system of financing production credit in the US is shown in Figure 2.3 (Turvey 2006):

Figure 2.3: Financing Production Credit in the United States



The system begins with the demand from a farmer. The farmer obtains a loan from the Production Credit Association on reasonable terms, and contributes 5% of this loan to paid in capital to the association and in turn the farmer would receive dividend paying Class B shares. The PCA was enacted with an 'equity' investment from the Production Credit Corporation, which received dividend paying, non-voting shares in return which was the purpose of the Corporation. The funding of PCA loans was done through the 12 regional Intermediate Credit Banks set up in the 1923 Act. These banks obtained funds by selling debentures and bonds to investors. Thus the system was self-sustaining and did not require the use of deposits (as with a commercial bank) to obtain capital (Turvey 2006).

As the depression came to an end, debates ensued about the future of the FCA. The dominant issue in the debates was the future of the FCA and whether it should remain as a stand-alone administration or be absorbed as an agency of the Department of Agriculture. The decisions to integrate the USDA came about with a number of recognitions about cooperative finance in general, including the low membership interest in cooperatives. As opposed to the system of the past were appraisals were based on self-fulfillment of market prices, the FCA began to appraise all land before a mortgage based on economic progress, cash flows, and repayment ability.

In retrospect, the presence of the FCA showed to be both effective and necessary. Without the existence of the FCA, the higher payment requirements for farmers would likely have led to greater rates of risk and foreclosures, which would have led to a collapse in land prices (Turvey 2006). It can be theorized that the actions of the FCA during the depression preserved far more wealth in agriculture than it was given credit for. Due to the guarantees in place, lenders would be more temped to loan to the market value rather than the land's economic value which would again, lead to land price speculation. It was also speculated by Myers that the FCA incorporation into the Department of Agriculture, allowed it to become a part of the political process and thus used in the future as a vehicle of policy (Turvey 2006). As explained by Smith and Jensen (1990) the necessity of the FCS was to address adverse selection and systematic risk for farmers. In their research, the results suggest that the FCS has behaved consistent with this theory, and give further explanation to its importance in agriculture.

As the second portion of this thesis aims to evaluate the effectiveness of the Farm Credit System and the Farm Service Agency against Commercial Banking, it is important to note exactly what their roles are and how we define them. The Farm Credit System is defined as a borrower-owned, permanent system of agricultural credit and rural credit across America. It is a Government Sponsored Enterprise that presently provides more than 40% of the credit in rural America (USDA, 2015). The Farm Service Agency is directed more as a lender of last resort for emergency credit, administering farm commodity, crop insurance, credit, environmental, and emergency assistance programs for agriculture (USDA, 2015).

2.4 Using credit in production decisions

The question then becomes; why do we care about the development of institutions for agriculture as described above? The reasons being that any form of industrial and agricultural growth will be constrained by liquidity. In the next two sections, 2.4 and 2.5, we develop more fully the role for the relationship between credit and agricultural production and credit and longer term assets.

Without the availability of credit, farmers become constrained to purchase equipment and inputs, which inhibits the expected output yields. For example, in Shee and Turvey (2012) and among others, they empirically illustrate how an increase in capital from borrowing will increase the output of production, giving the economic basis of the demand for credit. To summarize the model, the output function is given as:

$$Y = Y\left(P, x\left(r, D\right)\right) \quad (2.1)$$

where Y=output, P=price of output, x=inputs, r=interest rate, and D=debt available.

Farmers are constrained to create more output and the effects of the availability of credit are shown in the equality:

$$dY = \frac{\partial Y}{\partial P} dP + \frac{\partial Y}{\partial x}\frac{\partial d}{\partial r} dr + \frac{\partial Y}{\partial x}\frac{\partial x}{\partial D} dD \quad (2.2)$$

where the last term is equal to:

$$\frac{\partial Y}{\partial x}\frac{\partial x}{\partial D}\frac{\partial D}{\partial i} \approx \frac{\partial Y}{\partial i} \quad (2.3)$$

In the equality, $\frac{\partial Y}{\partial P} dP$ is the output price effect, $\frac{\partial Y}{\partial x}\frac{\partial d}{\partial r} dr$ is the cost effect where r is the input cost and $\frac{\partial Y}{\partial x}\frac{\partial x}{\partial D} dD$ is the effect of credit on the output. Without debt, or credit, available for the production function, the increase in output is restricted to the first two terms:

$$dY = \frac{\partial Y}{\partial P} dP + \frac{\partial Y}{\partial x} \frac{\partial d}{\partial r} dr \qquad (2.14)$$

By forgoing credit, farmers do not have the opportunity to expand their output as much as possible with the use of credit. This results in a less than optimal income and welfare level. The relationship between the demand for credit and the interest rates is also important as it holds influence on production decisions. For example, when farmers have a limited amount of cash, meaning they are short on liquidity, they are constrained to purchase equipment and inputs without the availability of credit. As the use of credit creates both a loss from the interest costs as well as a loss in liquidity, farmers are assumed to only borrow what they need, and not borrow for the sake of borrowing. Thus, there is a complementary relationship between other inputs and credit, as farmers use credit to purchase other inputs, not to replace them.

2.5 How interest rates affect farm land values

In order to understand how the interest rates can affect various inputs, we present a simple long-term asset value model to depict the value of farmland subject to changes in the cost of capital. This model also depicts the elasticities and shows how the interest rate can affect the elasticity of input demands.

To begin, let V be the designation for land value. The value of land should equal the present value of the economic rent derived from the land including all operating cash and an allowance for farmer's labor. Thus, the value of the farm land is of the form:

$$V = \sum_{t=1}^{T} \frac{A_t}{(1+r)^t} \qquad (2.5)$$

Where t is the number of years, r is cost of capital (interest rate) and A is the asset value in this case of land. If $T = \infty$, the value of the farm land is then:

$$V = \frac{A}{r} \quad (2.6)$$

meaning the land value bid-price is computed as a simple perpetuity. If we break the interest rate down into the return on asset (ROA), we see that:

$$r = ROA = \frac{E}{A} ROE - \frac{D}{A} i \quad (2.7)$$

where E is the value of equity, D is the amount of debt, ROE is the return on equity, and i is the cost of capital. The value of equity is defined as:

$$E = A - D \quad (2.8)$$

to define the value of the debt to asset ratio, the following simplification is needed:

$$\frac{E}{A} = \frac{A - D}{A} = 1 - \frac{D}{A} = 1 - \delta \quad (2.9)$$

Thus the value of farm land can also be described as:

$$V = \frac{A}{(1-\delta)ROE - \delta i} \quad (2.10)$$

In order to find the elasticity of the value of farm land with respect to the value of the cost of debt we find that:

$$\frac{\partial V}{\partial i} = \frac{-\delta A}{((1-\delta)ROE - \delta i))^2} < 0 \quad (2.11)$$

which shows that as the interest rates increase, there is a negative effect on the price of land as we could expect. The land-price elasticity can be defined as:

$$\varepsilon = \frac{\partial V}{\partial i} \frac{i}{V} \quad (2.12)$$

Which can be broken down into:

$$\varepsilon = \frac{-\delta A}{((1-\delta)ROE - \delta i)^2} \frac{i((1-\delta)ROE - \delta i)}{A} \quad (2.13)$$

$$\varepsilon = \frac{-i\delta}{(1-\delta)ROE - \delta i} < 0 \quad (2.14)$$

This last equation shows that the elasticity of land with respect to credit is a negative value; the percentage change in the value of land given a 1% increase in the cost of long-term borrowing is negative. Of course we do not know specifically what this value is, however, this study aims to investigate this. How we measure elasticities is influenced largely by the availability of debt and other inputs. Because the elasticity is going to be responsive to a multitude of factors, we ought not to be surprised if we see differences in debt across states and time.

To further investigate the relationship between the elasticity and the other variables, the effects of the return on equity, the cost of capital, and delta are found by taking the partial derivative of the elasticity. For example, the effect of delta (where $\delta = D / A$), on the elasticity is of the form:

$$\frac{\partial \varepsilon}{\partial \delta} = -\frac{i \ ROE}{(ROE - \delta(i + ROE))^2} < 0 \quad (2.15)$$

This derivative of the elasticity with respect to debt to asset ratio suggests that the joint elasticity between land and interest rates is sensitive to the local credit environment or the global credit environment at that time. From the above equation, the effect of an increase in the value of debt (described as delta) on the elasticity, holding all else constant, will cause the absolute value of the elasticity to decrease. In other words, as the value of delta increases the value of the debt to asset ratio increases and the elasticity becomes more inelastic.

Secondly, the effect of the ROE on elasticity is shown as:

$$\frac{\partial \varepsilon}{\partial ROE} = -\frac{(\delta - 1)\delta i}{(ROE - \delta(i + ROE))^2} \quad (2.16)$$

where the ROE is measuring profits. This measurement of profit is an endogenous relationship which is determined by the mix of long and short-run inputs. Though the ROA (which is the revenue less costs), a linkage for the duality work is provided. This effect of ROE on elasticity shows the dependency between the profits and elasticity, which justifies our model development in Chapter III and provides the reasoning for the duality framework we use. We can see in this equality, when the ROE increases (the firm is able to increase profitability), holding all else constant, the absolute value of the elasticity becomes smaller. This suggests that an increase in the ROE allows for the elasticity to become more inelastic.

Finally, the effect of interest rate on the elasticity is shown as:

$$\frac{\partial \varepsilon}{\partial i} = -\frac{(\delta - 1)\delta ROE}{(ROE - \delta(i + ROE))^2} \quad (2.17)$$

This final derivative shows that as the interest rate increases, the elasticity will again, become more inelastic.

These relationships, 2.15, 2.16, 2.17, provide a conceptual basis for what follows in terms of long-run elasticities. Ultimately, in Chapter VI we will provide evidence that these results hold true generally. However, the interaction between credit and production is a much more complex process with dynamic adjustments that need to be accounted. These topics, the relationships between credit, agricultural inputs, and long-term investments, are explored in more detail in Chapter III and form the fundamental basis for our short and long term elasticity estimates.

2.6 Summary

By providing a history of Agricultural credit in the United States as well as an overview of the Farm Credit System since inception, this chapter set the stage for understanding why credit is so important to the production process. Through the examination of the rise and fall of Land Banks, and the eventual implementation of the FCS as a GSE, we can see that the availability for agricultural credit has been a continuous debate across the US, and continues in present.

Following Shee and Turvey (2012), we show how credit availability constrains farmers to grow their business, as well as the rationale of credit's effect on liquidity. Finally, this chapter provided a mathematical approach for illustrating the cost of credit on land value. This was followed by a discussion of the partial derivatives of interest and its effects from ROE, debt, and cost of capital.

As the last two sections developed more fully the role for the relationship between credit and agricultural production and credit and longer term assets. This chapter provides evidence to support our hypothesis for including credit into the production process.

CHAPTER III

METHODS AND ECONOMETRIC SPECIFICATION

3.1 Introduction

Fundamental to understanding credit demand in agriculture is the robust estimation of credit demand elasticities. As agricultural credit is generally fungible, we have to look at it not only in relationship to its own price but in relationship to credit input use and on-farm investment. This chapter develops the dynamic duality structure necessary to deal with not only the fungibility of credit but on how credit impacts the demand for annual inputs and long-term investment. In addition, with respect to Objective 3 which examines the role of the Farm Credit System and Commercial Banking, this Chapter will end with a simplified structure to illustrate the potential relationship between demand for credit within the Farm Credit System and the demand for credit in the Commercial system.

In order to complete these objectives, this chapter will examine the models and methods employed in both sections of this thesis. To complete the three objectives set out in Chapter I, this thesis incorporates three dual function models and an econometric specification. To begin, an analysis of the duality model will be discussed, followed by an examination of the theorems required for duality. Next, a list of the advantages and limitations of using a dual function model will be presented, superseded by the motivation to include credit in the production function for agriculture. Finally, an examination of the three dynamic generations will be analyzed and discussed. To complete the third objective described in Chapter I, elasticities calculated from the Dynamic model will be used as control variables to examine the effectiveness of the Farm Credit System in the U.S.

3.2 Three Fundamental Dual Functions

There are three fundamental dual functions in production theory: the profit function, the cost function, and the production function. The two main dual functions used in agriculture include the cost function, which is used to estimate Hicksian input demands as well as to attain information regarding properties of the underlying production function, and the profit function, which allows estimation of Marshallian factor demands with output supply responses. An important feature of these dual functions that separates them from their primal counterparts, is that their dependent variable is derived by optimization. As explained by Young et al, in the optimization process, the primal function is referred to as 'the direct objective function' and the dual function is referred to as the 'indirect objective function.' In this process, the indirect objective function represents the optimal value of the direct objective function for any value of the parameters of the optimization problem. Regularity conditions are imposed on the indirect functions in order for the derivations to be consistent with their primal counterparts.

The Dual Profit Function

The dual profit function is a function of output and input prices $\pi = \pi(P_y, P)$, where π, P_y, and P show profit, output prices and input prices. This function displays the maximum profit a producer can achieve given their technology and price level. It can be derived by maximizing the primal profit function with respect to inputs and solving for the factor demand equations. Following this derivation, the factor demand equations are substituted back into the primal profit function. This function must follow these regularity conditions:

- it must be continuous with respect to input (factor) and output prices;
- it must be homogenous of degree one in input and output prices;

- it must be non-decreasing in output prices and non-increasing in input prices; and
- it must be quasi-convex in input and output prices.

The Dual Production Function

The dual production function is a function of input prices and costs Y=Y(P,C) where Y and show output and costs of production respectively. This function gives the maximum output available given the technology, input prices, and budget constraint. In order to solve for this function, the primal production function must be maximized with respect to inputs and solving for the constant-cost input demand functions. Finally, the demand functions must be substituted into the primary production functions. The dual production function also has regularity conditions which include:

- it must be continuous with respect to input prices and cost;
- it must be homogeneous of degree zero in input prices and cost;
- it must be non-increasing in input prices and non-decreasing in cost; and
- it must be quasi-convex in input and output prices.

The Dual Cost Function

In order to express the minimum level of cost in terms of input prices and output level, the dual cost function is used. The dual cost function, C=C(P,Y) is derived by minimizing the total factor cost subject to an output constraint, solving for the conditional factor demands, and the substituting the factor demand expressions into the original total factor cost function. The regularity conditions for this function include:

- it must be continuous with respect to input prices;

- it must be homogeneous of degree one in input prices;
- it must be non-decreasing in input prices and output; and
- it must be at least quasi-concave in input prices.

3.3 The Envelope Theorem and Three Fundamental Lemmas

The Envelope Theorem establishes the equality between the indirect objective function and the partial derivatives of a direct objective function. Using the Envelope Theorem, only the direct effects of a change in an exogenous variable needs to be considered despite the ability of the exogenous variable to enter the maximum-value function indirectly as part of the solution to the endogenous choice variable (Chiang). This theorem can be used to derive the following lemmas of duality, Hotelling's Lemma and Shephard's Lemma.

Hotelling's Lemma states that the partial derivatives of the maximum value of the profit function yields the firm's input-demand function and the supply function (Chiang). As described by Young et al, the negative partial derivative with respect to inputs price yields the ordinary factor demand function:

$$\frac{-\partial\pi(P_y,P)}{\partial P_y} = X_i(P_y,P) \qquad (3.1)$$

and the partial derivative with respect to output price yields the output supply function (Young et al):

$$\frac{\partial\pi(P_y,P)}{\partial P_y} = Y(P_y,P) \qquad (3.2)$$

This Lemma is crucial as it gives the comparative static derivatives from the profit function by allowing the inputs to adjust to any parameter change (Chiang).

Shephard's Lemma is imperative to the duality model as it incorporates a minimization problem for an expenditure function. In this lemma, a consumer's minimization problem is constructed by using a Lagrangian multiplier to find the first order conditions. These conditions give the input expenditures as a function of their prices and fixed utility by substituting the first order condition values into the Lagrangian multiplier. This will give the expenditure function (Chiang). The constant-output (Hicksian) factor demand function is derived as:

$$\frac{\partial C(P,Y)}{\partial P_i} = X_i(P,Y) \qquad (3.3)$$

As the resulting input demand equation is conditional on the level of output it is also called the conditional factor demand. Finally, one of the fundamental aspects of Shepard's Lemma is that it makes it possible to derive the production function from the cost function since the cost function contains all the relevant economic aspects of the production technology (KTB).

Roy's Identity is an application of the Envelope Theorem. This identity states that the individual consumer's Marshallian demand function is equal to the negative of the ratio of the two partial derivatives of the maximum value function:

$$-\left(\frac{\partial Y(P,C)/\partial P_i}{\partial Y(P,C)/\partial C}\right) = X_i(P,C) \qquad (3.4)$$

These lemmas are essential for the development of the duality models that will be presented at the end of this chapter.

3.4 Advantages and Limitations of Dual Approaches

The duality model has theoretical and empirical advantages and limitations. The most prominent advantages of this model include:

1. Consistency can be ensured through proper allocation of the dual functions because of the restrictions imposed by economic theory.
2. Duality allows for the empirical analysis of multiple-product firms and industries as well as analyses of entire demand or supply systems.
3. The functional forms used in dual functions impose fewer restrictions and therefore are more flexible than many popular production functional forms.
4. Simple estimation methods, such as generalized least squares, may be employed as duality yields explicit reduced forms with prices as independent variables.
5. Dual approaches are more simple than primal approaches in deriving economic relationships.

On the other hand, the duality approach has limitations as well:

1. Valid results require identifying both the objective function and constraints in addition to selecting the appropriate dual approach, as dual functions contain data on both the nature of technology and assumed rational behavioral response. Thus, an unknown constraint or ineffective market could weaken the dual approach.
2. The appropriate dual approach must be chosen given the researchers objective to fit the intended policy interpretation.
3. In order to obtain an efficient duality model, the researcher needs accurate price data that exhibits some dispersion.
4. Dual functions will often present estimates of economic measures, such as elasticities, that are very sensitive to data compositions and variable construction procedures.

It is imperative to consider these advantages and limitations while constructing a dual cost function model as they can be influential.

3.5 Motivation of credit

In 1968, Baker illustrated the need for including credit as an input into the production function. He explains that the effects of credit, defined as borrowing capacity, are essential to liquidity value as increasing loans generates a cost from the loss of liquidity. This loss, which has value, combined with the interest charges on loans, can have an impact on the production capabilities of a firm (Baker). Thus he explains, credit should be managed as an asset due to its important implications for production decisions.

As credit is not without the cost of interest, farmers will only borrow credit when they are constrained by liquidity to purchase other inputs. Therefore, the demand for the credit will be conditional on the demand for other inputs and output. D=D(X,P,r,Y) where (X,P,r,Y) is a vector of Hicksian factor demand functions as a function of input prices (P), interest rate (r) and the output (Y).

Typically, in production it is assumed that credit is used to replace existing inputs or upgrade them, for example machinery, or to purchase variable inputs, such as fertilizer. Therefore, credit and inputs generally have a complementary relationship, where a price of credit increase would lead to a decrease in the demand for inputs. Similarly, when the price of inputs increase, the demand for these inputs would decrease, and therefore credit would also decrease.
The above discussion assumes costs derived from transactions and use of physical inputs thus are easily measured in volume and price. However, in this study we add to the mix the cost of debt and this requires some specific assumptions.

Ultimately, we use a translog cost function with nine variable and quasi-fixed cost shares considered. Here we provide a more simple representation of the translog cost function to illustrate how interest rates and costs are treated.

Consider the following translog cost function for a single output of a single input, and an interest charge:

$$C = C(Y, P, r) \quad (3.5)$$

where C=total cost;

Y=Total inputs;

P=price of inputs; and

r= the interest rate on credit.

From this step, we can use duality to estimate parameters of the underlying production function. Thus by treating r as a price of an input, the cost function under duality will be of the translog form:

$$\ln C = \ln\alpha + \gamma_1 \ln P + \gamma_2 \ln r + \frac{1}{2}\gamma_3 \ln P \ln r \quad (3.6)$$

where ln= natural logarithm, and $\alpha, \gamma_1, \gamma_2, \gamma_3$ are coefficients to be estimated.

Differentiating with respect to the price of inputs and interest rate gives:

$$\frac{\partial \ln C}{\partial \ln P} = \gamma_1 \ln P + \frac{1}{2}\gamma_3 \ln r \quad (3.7)$$

$$\frac{\partial \ln C}{\partial \ln r} = \gamma_2 \ln r + \frac{1}{2}\gamma_3 \ln P \quad (3.8)$$

which can be written as:

$$\frac{\partial \ln C}{\partial \ln P} = \frac{\left(\frac{\partial C}{\partial P}\right)P}{C}$$

$$\frac{\partial \ln C}{\partial \ln r} = \frac{\left(\frac{\partial C}{\partial r}\right)r}{C}$$

By using Shepard's Lemma, we can convert equations 3.7 and 3.8 into cost-share questions, using:

$$\frac{\partial C}{\partial P} = x_1^* \quad (3.9)$$

$$\frac{\partial C}{\partial r} = x_2^* \quad (3.10)$$

where x_1^* and x_2^* are the optimal amounts of x_1 and x_2 where they show the points of least cost combination on the expansion path. In this example, x_1^* represents the demand for the input and x_2^* represents the optimal amount of credit. This form assumes that credit is, like other inputs, of tangible form. However, while the interest expense is no doubt a deduction from profits or addition to costs, it is fungible across input classes. Our assumption must be that it is evenly dispersed across all inputs of its class (short term or long term), and thus has some homothetic properties in term of separability. For example, assume the cost of purchasing two inputs using operating credit:

$$C = x_1P_1(1+r) + x_2P_2(1+r) \quad (3.11)$$

this can be expanded as:

$$C = (x_1P_1 + rx_1P_1) + (x_2P_2 + rx_2P_2) \quad (3.12)$$

$$C = x_1P_1 + x_2P_2 + r(x_1P_1 + x_2P_2) \quad (3.13)$$

In 3.13 it shows that the loan quantity as input is endogenous to the optimal quantity of inputs. It is easily arguable that it satisfies the regularity conditions of homogeneity of degree 1, thus as the price of inputs rises or falls, the cost of credit rises or falls in the same proportion. This also satisfies general convexity conditions in the sense that as interest rates rise, credit demand will fall.

3.6 Third Generation Dynamic Model

As described earlier, dynamic models allow for the adjustment of inputs towards their optimal level as opposed to forcing a complete and total adjustment. Due to the existence of unobserved adjustment costs associated with the variation of inputs and outputs, a period of adjustment is essential. As Nadiri and Rosen observe, the quantity of physical capital cannot rapidly adjust forgoing significant economic adjustment costs. As well, because of underlying differences in inputs, the adjustment rates will differ between inputs. As intuition suggests, land will adjust more slowly than seed due to the nature of the inputs. Land is fixed, whereas inputs such as seed need to be adjusted for each planting season.

This section describes the rationale presented by Berndt, Morrison, and Watkins (BM&W) which is summarized by Kimble, Turvey, and Weersink (KTW). They show that a third generation dynamic model is the ideal model for this research as it not only yields interrelated factor demands, but it also provides a well-defined measure of short, intermediate, and long-run price elasticities by explicitly incorporating dynamic optimization.

The third generation of dynamic models are based directly on dynamic economic optimization and incorporate costs of adjustment for the quasi-fixed factors. This allows for the speeds of adjustment of the quasi-fixed factors which are variable and endogenous rather than fixed and exogenous. Also, the short-run variable input demand equations can be interpreted as utilization equations as they depend on variable input prices and the quantities of quasi-fixed inputs and outputs. Finally, the quasi-fixed inputs can adjust in quantity and the rate of utilization as the variable inputs adjust from the short to the long run (BM&W).

The theoretical foundations for the third generation model is credited to R. E. Lucas (1967a,b), L.J. Lau (1976), D. McFadden (1978), and M.J. Vanden Dungen (1992) . A simple explanation of the theory is as follows.

A production function is defined as:

$$Y = F(v, x, x', t) \quad (3.14)$$

Where Y is the output, v shows the variable inputs, x represents the quasi-fixed inputs, x' is the change in the quasi-fixed input levels, and t is the time variable. If we allow the levels of the quasi-fixed inputs to vary ($x' \neq 0$), the output will fall due to the requirement of devoting resources to changing the stock rather than producing more output.

In the short run, firms can be regarded as minimizing normalized variable costs subject to the variable input prices, output, quasi-fixed inputs, and changes in the quasi-fixed input levels. Consequently, the long run issue facing the firm is to minimize the present value of the future stream of costs.

The accumulation equations for the quasi-fixed inputs and the short-run demand equations for variable inputs (utilization equations) can be obtained once the functional form for the normalized restricted cost function is specified. By summarizing the dynamic time path of factor demands, the short, intermediate, and long-run price and output elasticities can be derived. The short-run elasticities are described when x is fixed, the intermediate elasticities are defined when x has partially adjusted by M (the matrix of adjustment coefficients), and the long-run elasticities are found when $x' = 0$ and x has fully adjusted to x^*. This generation of dynamics also allows for testing whether an input is variable or fixed by reviewing whether the elements of M^* are close to unity.

3.7 Model Development

As discussed in Chapter I, this thesis incorporates three models to examine the demand for credit. The first, the Static model, is the most restrictive of the models as it assumes that the inputs adjust instantaneously in each period to their equilibrium values. The second, the Partial Static model, is slightly less restrictive. This model allows some inputs to be variable and some to be quasi-fixed. Finally, the third, the Dynamic model, is the least restrictive model. This model allows for an adjustment period or a partial change toward the equilibrium values of inputs, as opposed to the static model which forces a complete and total adjustment for each input in every period.

3.7.A Static Model

The Static model contains eight cost share equations to be estimated. Cost share equations are defined as the input expense as a share of total expenditures. These cost shares are included for all nine inputs: feed expenditures, operating credit expense, labor expense, crop input expense, livestock expenditures, real estate credit expense, land expense, machinery expense, and other expenditures. A further explanation of the data and variables will be continued in Chapter IV. The static model is the most prohibitive model, and assumes that the elasticities estimated for the inputs are long-run values.

In the static model, the cost shares are estimated using the seemingly unrelated regression method, which is described in detail in Chapter IV. This method is used to account for the presumably related standard errors, cross equation restrictions, and the correlation of residual errors. This also allows the model to be constrained in order to make the assumption that the effect of a variable, x, on the cost share, y, is the same as the effect of variable, y, on cost share,

x. For example, the effect of the price of land on the cost share of livestock should be equal to the effect of livestock on the cost share of land.

Eight cost shares will be estimated in this model as the ‘other’ input cost share will be omitted in order to avoid singularity. These cost shares will be estimated of the form:

$$CS_i = \alpha_i + \sum_{j=1}^{6} \gamma_{ij} (\ln P_j / P_9) + (\ln P_7 / P_9) + (\ln P_8 / P_9) + \sum_{y=c,l} \beta_{yi} \ln Y_y + \beta_{it} T \tag{3.15}$$

where the cost shares of each input are functions of the natural log of each inputs price relative to the ‘other’ input price, the natural log of the outputs (crops and livestock), and the effect of a time trend. In order to show the effect of the types of credit, P_7 and P_8 , show the price for short and long term credit, $r_{stinterest}$ and $r_{ltinterest}$, respectively. This model assumes that each of the inputs will adjust to the ideal value in each time period.

Once the cost shares are estimated, the elasticities will then be calculated. The methods and formulas for estimating the Hicks-Allen elasticities of substitution and price elasticities will also be discussed further in Chapter IV.

3.7.B Partial Static Model

The Partial Static model contains less restrictions than the Static model. In this model, four cost shares are estimated for feed, operating credit, labor share, and crop input share. Cost shares are estimated of the form:

$$CS_i = \alpha_i + \sum_{j=1}^{5} \gamma_{ij} \ln P_j + \sum_{k=6}^{9} \beta_{ki} \ln Z_k + \sum_{y=c,l} \beta_{yi} \ln Y_y + \beta_{it} T \tag{3.16}$$

Where Z denotes is the quantity of the variables that are quasi-fixed. These variables will adjust partially to the equilibrium value due to their restrictive costs associated with adjusting to exogenous changes in the period. Specifically, the quasi-fixed variables in the partial static model include livestock expenses, long-term credit expense, land expenditures, and machinery expenses. The cost shares estimated in the Partial Static model are functions of the natural log of each of the input prices for the first fives inputs (including feed price, short-term credit price, labor share, crop input share, and 'other' input prices), the quantity index for the remaining four inputs (including livestock, long-term credit, land expenditures, and machinery expenditures), the natural log of the outputs livestock and crop, and the effect of the time trend.

The elasticities for this model will be calculated using the same formulas as the static model, however, as the elasticities for the four cost shares are dependent on the quasi-fixed inputs, they are partial elasticities. This model and its elasticities will also be examined in depth in Chapter IV.

3.7.C Dynamic Model

The third model presented in this thesis is the least restrictive model. The Dynamic model is similar to the static model in that it estimates the same eight cost shares, however, the inputs are not required to shift instantaneously to their equilibrium values. The model will be estimated from the form:

$$CS_t - CS_{t-1} = M(CS_t^* - CS_{t-1}) \quad (3.17)$$

where CS_{t-1} is a lagged cost share, CS_t^* is a predicted optimal level cost share, and M is the adjustment matrix. The adjustment matrix, which will be discussed further in Chapter IV, allows each input to adjust to the optimal level at its corresponding pace.

The elasticities for the dynamic model are broken in two time-frames. The long-run elasticities are calculated from the formula given in the static model. The short-run elasticities are calculated using the Allen-Uzawa substitution and price elasticity equations. The Dynamic model and its elasticities will also be discussed further in Chapter IV.

3.8 Farm Credit System Effectiveness

By objective 3 set out in Chapter I, we want to also look at the macro credit relationships between the FCS and the CB. However, to investigate this relationship without understanding the underlying attributes of credit demand would be incomplete. In Chapter IV, we develop these ideas more formally, though at this point, it is worth indicating that the differential demands for credit which we assume adjust to supply will require understanding the elasticities.

This section of the thesis is designed to explore the effectiveness of the Farm Credit System (FCS) in the US since its inception. Once the three dual functions described above have been completed, three of the elasticities will be used as control variables in the econometric specification created for Farm Credit. As explained in Chapter II, the FCS was mandated to provide credit to farmers in economic downturns, which is examined by comparing the relative lending of both the FCS and the Farm Service Agency (FSA) to the lending of the Commercial Banking (CB) in the agricultural sector. Relative lending of both the FCS and FSA are calculated as the percentage difference in lending for FCS (FSA) minus the percentage difference of CB lending. Thus when the FCS (FSA) is increasing its lending relative to CB, the variable should become more positive, and when the CB is lending more relative to FCS (FSA), the variable should become more negative. As this study aims to investigate the lending behaviour during economic downturns, variables to account for macro-economic conditions are included. These variables include: farm income, US real GDP, number of farm bankruptcies, US treasury yield, number of farms, farm population, short term interest elasticity, long term interest elasticity, and land elasticity. The change in relative lending can be shown as:

$$\left(\frac{FC_t - FC_{t-1}}{FC_{t-1}}\right) - \left(\frac{CB_t - CB_{t-1}}{CB_{t-1}}\right) \quad (3.18)$$

Where FC_t= the amount of lending distributed in a given time period, t, from the a farm credit organization (including FCS and FSA);

FC_{t-1}= the amount of lending from a farm credit organization in the previous time period; CB_t= the amount of lending distributed by the commercial banking system in time t; and

CB_{t-1}= the amount of lending from the commercial banking system in the previous time period.

As discussed above, the elasticities of long and short term credit capture not only the direct effect of interest rate change, but also change in input and output prices and quantities. If the short term elasticities are responsive to contemporaneous economic conditions, the point elasticities will rise and fall as conditions change in time. Part of our investigation is to examine the differences in Farm Credit and Commercial Bank lending over time, and the interest rate elasticities as derived above are important control variables. For example, in Chapter IV we build on the relationship:

$$\left(\frac{FC_t - FC_{t-1}}{FC_{t-1}}\right) - \left(\frac{CB_t - CB_{t-1}}{CB_{t-1}}\right) = \beta_0 + \beta_1 \varepsilon_{credit} + e \qquad (3.19)$$

The elasticities described above are taken from the Dynamic model described in section 3.7.C. The elasticities for short-term interest, long-term interest, and land price elasticity are all weighted by the average expenditures for each state. The interest elasticity for each state is multiplied by the weight of the input expense for the respective state. These weighted elasticities are summed to create a weighted average elasticity. We weighted the elasticities in order to create an average that would not be influenced by states and their relative expenditures. The weighted elasticities are used to capture the behavioural aspects of lending that would not be captured by the other models. For example, the long-term weighted elasticity shows the sensitivity of farmers to increases in the interest rate for real estate.

3.9 Summary

This Chapter aimed to provide a discussion of the theory and models presented in this thesis. Firstly, it included an overview of duality, an evaluation of the three fundamental lemmas, and an interpretation of the Envelope Theorem and the three essential lemmas that incorporate the theorem.

Secondly, this was followed by a listing of the advantages and disadvantages of using a dual approach in this research. As listed above, we can see that the advantages of using this method outweigh the costs; however, they are still points that need to be addressed and considered.

Thirdly, the rationale for including credit in the production function is provided. This extends from the foundation built by Baker in 1968, which precedes the example of the translog cost function for a single output of a single input, and an interest charge.

Fourthly, an in depth analysis of the third generation dynamic model is presented, including the rational by BM&W, describing one of the key points of the third generation dynamic model as being a well-defined measure of short, intermediate, and long-run price elasticities by explicitly incorporating dynamic optimization. This section is followed by the model development for the duality portion of this thesis. Beginning with the Static model, which assumes that each of the inputs adjusts fully to the optimal level in each period, followed by the Partial Static model, which allows some of the inputs to be quasi-fixed, and finally the Dynamic model, which is a less restrictive form of the Static model.

Finally, the methods to identify and analyze the effectiveness of the Farm Credit System are presented. This objective is achieved by examining the changes in relative lending between Farm Credit and the Commercial Banking systems.

CHAPTER IV

DATA AND MODELS

4.1 Introduction

This thesis incorporates a time-series data set stretching from 1919-2013 with two distinct portions. The first section of data includes state level data, specifically examining at data for the five corn-belt states: Illinois, Iowa, Indiana, Missouri, and Ohio, as well as an average of these 5 states. This portion is used to examine the dual cost objective which utilizes three models: the Static model, Partial Static model and the Dynamic model. The Static model makes the assumption that the inputs adjust immediately towards their equilibrium value in each time period. This model differs from the Partial Static and the Dynamic models, which assume that some inputs only partially adjust in each period. The Partial Static model differs as it assumes some of the inputs are quasi-fixed. Similarly, the Dynamic model is also less restrictive than the Static model because it allows the quasi-fixed inputs to adjust partially through the use of a partial adjustment matrix. The second section includes national data for the US. This data is used to identify the effectiveness of the FCS during economic downturns. The variables are required to examine the relative lending between the FCS and the FSA compared to the CB system for both real estate and non-real estate loans.

4. 2 Data

The data is collected from the USDA annual statistical summaries, dating back to 1919 for both the Duality and Farm Credit System sections of this thesis. The Duality section explores only the five corn-belt states in order to keep the data set relatively homogenous. As the states share similar agricultural practices and climate, this avoids the problem of aggregating national agricultural data, which would be including many different cropping patterns and environments. The Farm Credit portion of this thesis uses national data for the lending patterns of commercial banks, the Farm Credit System, and the Farm Service Agency from 1939-2013. Tsigas and Hertel (1989) show that using state level panel data helps to avoid multicollinearity and simultaneity further than aggregate time-series data, due to the large number of observations. Using panel data will help to reduce bias and increase efficiency in the models.

4.2.A Duality Data

The annual expenditure data was broken into nine categories: total production expenses; crop expenses (including seed, fertilizer, and lime plus pesticides purchased); feed purchases; livestock and poultry expenses; contracted and hired labor expenses; land expenses (including net rent to non-operator landlords plus property taxes); non-real estate interest expense; real estate interest expense; machinery expense (including depreciation, repairs, plus fuel purchased); and other expenses (including electricity, insurance, and miscellaneous). All of the expenditure data was found in the USDA statistical summaries.

Output was divided into crops and livestock, measured in quantity indexes for the corn-belt region (USDA). The indices for hourly wage rates were also measured for the corn-belt region and the land values were measured by state as an index of average value per acre of farm real estate. Prices for all other inputs were collected at the national level from the USDA, as it was not available by state or region for the entire period.

Non-real estate interest expense used is the average cost of loans outstanding during the year through Production Credit Associations. The real estate interest expense is denoted as the average rate on new loans through the Federal Land Bank Associations (USDA). The other prices were collected at the national level from the statistical summaries (USDA). These prices paid by farmers for all production include: feed; feeder livestock; seed; fertilizer; pesticides; and machinery. These are national rates, as the regional or state rates were also not available.

4.2.B Farm Credit Data

This section incorporates data at the national level for the years 1939-2013. The dependent variables used in this portion are the relative lending of the FCS and the FSA compared to the CB system in both real estate lending and non-real estate lending. The independent variables include: farm income (in billions), US Real GDP, number of farm failures, US treasury yield on a one-year bond, farm population, and three elasticities calculated from the Dynamic Duality model that will be presented later in this chapter. The variables and their source are described in Table 4.1:

Table 4.1 Regression Variables for Farm Credit

Variable	Description	Source
Farm Income	Farm Income (billions)	USDA
GDP	US Real GDP	BEA
Failures	Number of farms that files for bankruptcy in a year	USDA
Treasury Yield	Treasury Yield on a one year bond	US Department of the Treasury
Population	Farm Population (000s)	USDA
LT Interest Elasticity	Estimated long-term interest elasticity weighted by interest expense (absolute value)	
ST Interest Elasticity	Estimated short-term interest elasticity weighted by interest expense (absolute value)	
Land Elasticity	Estimated land interest elasticity weighted by interest expense (absolute value)	

The elasticities used are averages of the corn-belt states from the Dynamic Duality model described further in this Chapter and include: the average short-term interest elasticity (weighted by state interest expense), average long-term interest elasticity (weighted by state interest expense), and the average land elasticity (weighted by state land expense).

4.3 Seemingly Unrelated Regressions

In order to find the estimates, the Seemingly Unrelated Regression (SUR) model[2] must be used to account for the restrictions imposed. SUR is described as a generalized version of a linear regression model consisting of regression equations that each has its own dependent variable and possibly a different set of exogenous explanatory variables (Greene, 2003). In SUR, equations are linked only by their errors, which gives the name, seemingly unrelated regressions.
This estimation model is required to account for the restrictions that specify $\beta_{ij} = \beta_{ji}$. SUR is equivalent to the Ordinary Least Squares (OLS) model when each equation contains exactly the same set of repressor independent variables with identical values (Greene, 2003).

Prior to estimating the SUR model, the examination must begin with a discussion of Zellner's method. In order to impose the restrictions for symmetry as provided by Shepard's Lemma, Zellner's method is required. When the V in the estimator is unknown, Zellner proposed the construction of a feasible estimator

$$b^* = \left(X'V^{-1}X\right)^{-1} X'V^{-1}y \quad (4.1)$$

Firstly, OLS must be applied separately to each equation in the list of the models:

$$\begin{aligned} y_1 &= X_1\beta_1 + u_1 \\ y_2 &= X_2\beta_2 + u_2 \qquad (4.2) \\ y_m &= X_m\beta_m + u_m \end{aligned}$$

---

[2] The SUR model is used as each equation is a valid linear regression on its own and can be estimated separately, however, since the error terms are assumed to be correlated across equations it is *seemingly unrelated.*

which enables obtaining the vectors of sample residuals e_1, e_2, e_m where

$$e_i = \left[I - X_i \left(X_i' X_i \right)^{-1} X_i' \right] y_i \quad \text{for i=1,…,m} \quad (4.3)$$

Secondly, the diagonal elements of σ_{ij} of Σ[3] are estimated by $s_{ii} = \frac{e_i' e_i}{n-k_i}$ and the diagonal

elements s_{ij} are estimated by:

$$s_{ij} = \frac{e_i' e_j}{\left(n-k_i\right)^{\frac{1}{2}} \left(n-k_j\right)^{\frac{1}{2}}} \quad (4.4)$$

where k_i denotes the number of columns in X_i.

Thus an estimated $\hat{\Sigma}$ matrix can be computed and substituted into b* to find a feasible estimator. This estimator is often referred to as SURE (seemingly unrelated regression equations) or SUR (seemingly unrelated regression) estimator, named after the title of Zellner's original paper. To follow Johnston, the gain in efficiency yielded by the Zellner estimator over OLS increases directly with the correlation between disturbances form the different equations and decreases as the correlation between the different sets of explanatory variables increases paper (Johnston, 1984).

Next a more in-depth explanation of SUR is required. To summarize Greene, beginning with the linear function

$$y_t = \Pi x_t + \varepsilon_t \quad (4.5)$$

and collect all T observations in this format, the system will appear as

$$Y' = \Pi X' + E' \quad (4.6)$$

---

[3] In this section, Σ is used to denote a matrix of variances and is not to be interpreted as the conventional summation.

Where each Π contains the parameters in the particular equation. Next, the partition of the set of dependent variables into two groups of M_1 and M_2 variables and the set of regressors into two sets of K_1 and K_2 variables is considered. The equation now becomes:

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}_t + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix}_t \quad (4.7)$$

$$E\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} |\mathbf{X} = \begin{bmatrix} 0 \\ 0 \end{bmatrix},\ Var\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}_t |\mathbf{X} = \begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix} \quad (4.8)$$

The restricted model with $\Pi_{12} = 0$ is of interest, as it has the effect of excluding x_2 from all the equations from y_1 (Greene, 2003). Greene shows the results obtained from this case are as follows. Firstly, the maximum likelihood estimator of Π_{11} when Π_{12} is equation-by-equation least squares regression of the variables y_1 on x_1 alone. Even with the restriction, the efficient estimator of the parameters of the first set of equations is equation-by-equation ordinary least squares. Secondly, the effect of the restriction on the likelihood function can be isolated to its effect on the smaller set of equations.

Subsequently, the maximum likelihood estimation of the unrestricted system must be considered. The function for this multivariate regression model appears as:

$$\ln L = \sum_{t=1}^{T} \ln f(y_{1t}, y_{2t} | x_{1t}, x_{2t})^4 \quad (4.9)$$

Where the mean and variance of the marginal distribution are:

$$E\left[y_{1t} | x_{1t}, x_{2t}\right] = \Pi_{11} x_{1t} + \Pi_{12} x_{2t} \quad (4.10)$$

$$Var\left[y_{1t} | x_{1t}, x_{2t}\right] = \Sigma_{11} \quad (4.11)$$

[4] Here the $\sum$ is now interpreted as the conventional summation.

$$E\left[y_{2t} \mid y_{1t}, x_{1t}, x_{2t}\right] = \left[\Pi_{21} - \Sigma_{21}\Sigma_{11}^{-1}\Pi_{11}\right]x_{1t} + \left[\Pi_{22} - \Sigma_{21}\Sigma_{11}^{-1}\Pi_{12}\right]x_{2t} + \left[\Sigma_{21}\Sigma_{11}^{-1}\right]y_{1t}$$

$$= \Lambda_{21}x_{1t} + \Lambda_{22}x_{2t} + \Gamma y_{1t} \quad (4.12)$$

$$Var\left[y_{2t} \mid y_{1t}, x_{1t}, x_{2t}\right] = \Sigma_{22} - \Sigma_{21}\Sigma_{11}^{-1}\Sigma_{12} = \Omega_{22} \quad (4.13)$$

Greene then shows the objective of the partitioning is to partition the log-likelihood function as:

$$\begin{aligned} \ln L &= \sum_{t=1}^{T} \ln f\left(y_{1t}, y_{2t} \mid x_{1t}, x_{2t}\right) \\ &= \sum_{t=1}^{T} \ln f\left(y_{1t} \mid x_{1t}, x_{2t}\right) f\left(y_{2t} \mid y_{1t}, x_{1t}, x_{2t}\right) \qquad (4.14) \\ &= \sum_{t=1}^{T} \ln f\left(y_{1t} \mid x_{1t}, x_{2t}\right) + \sum_{t=1}^{T} \ln f\left(y_{2t} \mid y_{1t}, x_{1t}, x_{2t}\right) \end{aligned}$$

Finally without the restrictions on the parameters, the log-likelihood can be maximized using its two parts separately. As $\Pi_{21}, \Pi_{22}, \Sigma_{21}$ and Σ_{22} are all free, unrestricted parameters, there are no restrictions imposed on $\Lambda_{21}, \Lambda_{22}, \Gamma,$ or Ω_{22}. Thus, in each case, the efficient estimators are equation-by-equation OLS. The first part produces estimates of Π_{11}, Π_{22} and Σ_{11} directly. From the second, the estimates of $\Lambda_{21}, \Lambda_{22}, \Gamma,$ and Ω_{22} are obtained. The relationships above are obtained from the restrictions (Greene, 2003):

$$\begin{aligned} \Pi_{12} &= \Lambda_{21} + \Gamma\Pi_{11} \\ \Pi_{22} &= \Lambda_{22} + \Gamma\Pi_{12} \\ \Sigma_{21} &= \Gamma\Sigma_{11} \\ \Sigma_{22} &= \Omega_{22} + \Gamma\Sigma_{11}\Gamma' \end{aligned} \qquad (4.15)$$

Once these restrictions are put in place, the model also calls for the fixation of the state dummy variables across the cost shares. The time trend is treated as a fixed effect where the model looks at the effect of the change of time rather than breaking it down into individual effects.

4.4 Estimating Equations

The models used in the duality portion of the thesis are based on the dual cost function which is described as the sum of the input prices multiplied by the respective output compensated demand for each of the n inputs:

$$C(P,Y) = \sum_{i=1}^{n} P_i X_i \qquad (4.16)$$

The actual model used is a nonhomothetic[5] cost function, which is more general than a homothetic function, as the ratios of cost-minimizing inputs demands are dependent on output with the former and are independent of the level of output with the latter (Binswager and Kako). The translog cost function exhibiting non-neutral technical[6] change is of the form:

$$\begin{aligned}\ln C = \alpha_0 &+ \sum_{i=1}^{8} \alpha_i \ln(P_i / P_9) + \sum_{y=c,l} \alpha_y \ln Y_y + \alpha_t T + \frac{1}{2}\sum_{i=1}^{8}\sum_{j=1}^{8} \gamma_{ij} \ln(P_i / P_9)\ln(P_j / P_9) \\ &+ \frac{1}{2}\sum_{y=c,l}\sum_{z=c,l} \gamma_{yz} \ln Y_y \ln Y_z + \frac{1}{2}\gamma_{tt} T^2 + \sum_{y=c,l}\sum_{i=1}^{8} \beta_{yi} \ln Y_y \ln(P_i / P_9) + \sum_{i=1}^{8} \beta_{it} \ln(P_i / P_9) T \\ &+ \sum_{y=c,l} \beta_{yt} \ln Y_y T \end{aligned} \qquad (4.17)$$

where:

ln= natural logarithm

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[5] A nonhomothetic cost function is more general than a homothetic function because the ratios of cost-minimizing input demands are dependent on output and in homothetic functions they are dependent on the level of output

[6] This is a non-neutral technical change function as all changes in factor shares are attributed to substitution and/or factor augmenting technical change

C=total cost or total production expenses;

α_0 =intercept;

P_i= Price of nine inputs (P_1= feed price, P_2= operating credit, P_3=wage rate, P_4=crop input price P_5=feeder livestock price, P_6= long term interest rate, P_7= land value P_8= machinery price, P_9=price index of other inputs)

Y_y= quantity index for two outputs (Y_C= crops Y_L=livestock);

T=Time trend;

$\alpha_i, \alpha_y, \alpha_t, \gamma_{ij}, \gamma_{yz}, \gamma_{tt}, \beta_{yi}, \beta_{it}, \beta_{yt}$ are coefficients to be estimated.

This cost function is non decreasing in input and output prices, due to the restrictions specified in Chapter III and is also continuous with respect to input prices. The restrictions that must hold in this model are set out by Chiang. He states that he cost function must be at least quasi-concave in input prices, which requires the function to be twice differentiable. According to Young's Theorem, two functions f_{xy} and f_{yx} will have identical values as long as the two cross partial derivatives are both continuous. Thus, the sequential order in which partial derivation is undertaken becomes immaterial, because f_{xy}=f_{yx} (Chiang). Young's Theorem thus states that the second cross partial derivatives must be equal which is imposed through the restrictions $\gamma_{ij} = \gamma_{ji}$ and $\gamma_{yz} = \gamma_{zy}$ for all i, j, y, and z. Lastly, in order for the cost function to be homogenous of degree one in input prices, the following restrictions must hold:

$$\sum_{i=1}^{9} \alpha_i = 1, \sum_{i=1}^{9} \gamma_{ij} = \sum_{j=1}^{9} \gamma_{ji} = \sum_{i=1}^{9} \beta_{yi} = \sum_{i=1}^{9} \beta_{it} = 0$$

which are made more specific as:

$\alpha_9 = 1 - (\alpha_1 + ... + \alpha_8)$

$\gamma_{i9} = -(\gamma_{i1} + ... + \gamma_{i8})$ *for i= 1,...,9*

$\beta_{y9} = -(\beta_{y1} + ... + \beta_{y8})$ *for y= c, l*

$\beta_{9t} = -(\beta_{1t} + ... + \beta_{8t})$

In order to impose these restrictions, each input price index was divided by the price index for 'other' inputs, P_9.

4.4.1 Static Model

The static model contains eight variable cost share equations. In order to estimate the cost-minimizing input demand equations, Shephard's Lemma must be employed. This means that the cost function (4.16) will be logarithmically differentiated with respect to input prices in order to obtain the cost share equations:

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i}{C} \bullet \frac{\partial C}{\partial P_i} = \frac{P_i X_i}{C} = CS_i \qquad (4.18)$$

for the i=1, …, n and where $\sum_i P_i X_i = C$. If $CS_i = P_i X_i / C$, it follows that $\sum_i CS = 1$ (the cost shares must sum to one).

The eight cost shares that will be estimated are of the form:

$$CS_i = \alpha_i + \sum_{j=1}^{8} \gamma_{ij} \ln(P_j / P_9) + \sum_{y=c,l} \beta_{yi} \ln Y_y + \beta_{it} T \qquad (4.19)$$

Where CS_i = Cost share for eight of the nine inputs (CS_1=feed share, CS_2=operating credit share, CS_3=labor share, CS_4=crop input share, CS_5=livestock share, CS_6=term credit share, and CS_8=machinery share) The cost shares are found by dividing the input expenditure by the total expenditures. 'Other inputs' is not included as an estimated cost share to avoid singularity, although it can be retrieved through the restrictions described above.

The static model is the most restrictive model in this thesis, as it assumes all inputs are variable, meaning in each equilibrium in each time period. This model assumes that the inputs fully adjust instantaneously so the estimated elasticities represent the long-run values.

The Hicks-Allen partial elasticities of substitution are calculated between inputs I and j for a general dual cost function, C, having n inputs. It is of the form:

$$\sigma_{ij} = \frac{C\ C_{ij}}{C_i\ C_j} = \frac{C}{\frac{\partial C}{\partial P_i}\frac{\partial C}{\partial P_j}} \frac{\partial^2 C}{\partial P_i \partial P_j} \quad (4.20)$$

where the subscripts i and j on C refer to the first and second partial derivatives of the cost function with respect to the input prices.

The estimated Allen partial elasticities of substitution between inputs i and j for the translog cost function are set as:

$$\sigma_{ij} = \frac{\gamma_{ij} + CS_i CS_j}{CS_i CS_j} \; i,j = 1, \ldots, n, \; but \; i \neq j \quad (4.21)$$

$$\sigma_{ij} = \frac{\gamma_{ij} + CS_i^2 - CS_i}{CS_i^2} \; i = 1, \ldots, n \quad (4.22)$$

Finally, the price elasticities are calculated as $\varepsilon_{ij} = CS_j \sigma_{ij}$ where CS_j is the cost share of the jth input. The equations for the price elasticities are formed as:

$$\varepsilon_{ij} = \frac{\gamma_{ij} + CS_i CS_j}{CS_i} \quad i,j = 1, \ldots, n \quad but \;\; i \neq j \quad (4.23)$$

$$\varepsilon_{ii} = \frac{\gamma_{ij} + CS_i^2 - CS_j}{CS_i} \; i = 1, \ldots, n \quad (4.24)$$

4.4.2 Partial Static Model

The partial static model consists of four cost share equations that are derived from a nonhomothetic restricted translog cost function of the form:

$$\ln VC = \alpha_0 + \sum_{i=1}^{5} \alpha_i \ln P_i + \sum_{k=6}^{9} \alpha_k \ln Z_k + \sum_{y=c,l} \alpha_y \ln Y_y + \alpha_t T + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \gamma_{ij} \ln P_i + \frac{1}{2}\sum_{k=6}^{9}\sum_{l=6}^{9} \gamma_{kl} \ln Z_k \ln Z_l$$
$$+ \frac{1}{2}\sum_{y=c,l}\sum_{z=c,l} \gamma_{yz} \ln Y_y \ln Y_z + \frac{1}{2}\gamma_{tt} T^2 + \frac{1}{2}\sum_{i=1}^{5}\sum_{l=6}^{9} \beta_{ki} \ln Z_k \ln P_i + \sum_{y=c,l}\sum_{i=1}^{5} \beta_{yi} \ln Y_y \ln P_i + \sum_{y=c,l}\sum_{k=6}^{9} \beta_{yk} \ln Y_y \ln Z_k$$
$$+ \sum_{i=1}^{5} \beta_{yk} \ln P_i T + \sum_{k=6}^{9} \beta_{kt} \ln Z_k T + \sum_{y=c,l} \beta_{yt} \ln Y_y T$$

(4.25)

Where VC= total variable cost defined as the sum of feed expense, operating credit expense, labor expense, crop input expense, and 'other' expense;

α_0 = intercept;

P_i = price index of the five variable inputs (P_1= feed price, P_2= operating credit interest rate, P_3= wage rate, P_4= crop input price, and P_5= price index of other inputs);

Z_k = quantity of the four-quasi fixed inputs (Z_6= quantity of feeder livestock expense, Z_7=quantity of long term payments, Z_8= quantity of land expenditures and Z_9= quantity of machinery expenditures);

Y_{yt} and T are defined in (4.17);

$\alpha_i, \alpha_k, \alpha_y, \alpha_t, \gamma_{ij}, \gamma_{kl}, \gamma_{yz}, \gamma_{tt}, \beta_{ki}, \beta_{yi}, \beta_{yk}, \beta_{it}, \beta_{kt}$ and β_{yt} are coefficients to be estimated.

As with the static model, the restrictions for the regularity conditions set out in Chapter III are also imposed on the Partial Static model. The symmetry conditions require: $\gamma_{ij} = \gamma_{ji}, \gamma_{kl} = \gamma_{lk}$ and $\gamma_{yz} = \gamma_{zy}$ for all i, j, k, l, y, and z. Homogeneity requires:

$$\sum_{i=1}^{5}\alpha_i = 1, \sum_{i=1}^{5}\gamma_{ij} = \sum_{j=1}^{5}\gamma_{ji} = \sum_{i=1}^{5}\beta_{ki} = \sum_{i=1}^{5}\beta_{yi} = \sum_{i=1}^{5}\beta_{it} = 0$$

which creates the specifications:

$$\alpha_5 = 1 - (\alpha_1 + \dots + \alpha_4)$$

$$\gamma_{i5} = -(\gamma_{i1} + \dots + \gamma_{i4}) \qquad \textit{for } i = 1, \dots, 5$$

$$\beta_{k5} = -(\beta_{k1} + \dots + \beta_{k4}), \quad \textit{for } k = 6, \dots, 9$$

$$\beta_{y5} = -(\beta_{yl} + \dots + \beta_{y4}), \quad \textit{for } y = c, l$$

$$\beta_{5t} = -(\beta_{1t} + \dots + \beta_{k4})$$

(4.26)

The actual model is comprised of four cost share equations that derived by employing Shephard's lemma on the variable cost function. The model is of the form:

$$CS_i = \alpha_i + \sum_{j=1}^{5}\gamma_{ij}\ln P_j + \sum_{k=6}^{9}\beta_{ki}\ln Z_k + \sum_{y=c,l}\beta_{yi}\ln Y_y + \beta_{it}T \qquad (4.27)$$

Where CS_i= Cost share for the four variable inputs (CS_1= feed share, CS_2= operating credit share, CS_3= labor share, CS_4= crop input share). Once again, the 'other inputs' cost share is not included in order to avoid singularity issues.

The quasi-fixed designation given to this model accounts for the partial adjustments of the last four inputs. The first four inputs plus 'other' inputs will fully adjust to the equilibrium levels each period, however, the last four inputs will only partially adjust because of the restrictive costs associated with adjusting to exogenous changes in a given period. The equilibrium values in this model will be found for the variable inputs conditional on the quasi-fixed inputs.

The elasticity estimates are found using the same equations as the static model, however, since the variable inputs are calculated conditional on the values of the quasi-fixed inputs, they are partial elasticities.

4.4.3 Dynamic Model

As described earlier, the Dynamic model is less restrictive version of the Static model. Similar to the Static model, it is based off the translog cost function (4.17) and uses the same eight cost shares. The difference between the models however, is that the static cost shares are represented as the long-run optimal values, CS_i^*. As in the partial static model, the first four inputs are variable inputs and the last four are quasi-fixed.

This model needed to be adjusted for the non-instantaneous adjustment of the quasi-fixed inputs using the partial adjustment model:

$$CS_t - CS_{t-1} = M(CS_t^* - CS_{t-1}) \quad (4.28)$$

Where CS^* is the vector of fully adjusted levels of CS. M is a n x n matrix of adjustment coefficients that determine the adjustment rate of CS to the fully adjusted model. As the inputs adjust at different rates than others to the optimal levels, their adjustment coefficients m_{ij} are found. The four inputs that adjust instantaneously will have coefficients that are restricted accordingly.

In order to solve for CS_t, equation (4.18) will be adjusted as:

$$CS_t = M\ CS_t^* + (1-M)CS_{t-1} \qquad (4.29)$$

Where the system of dynamic equations is:

$$\begin{bmatrix} CS_1 \\ . \\ . \\ . \\ CS_8 \end{bmatrix} = M \begin{bmatrix} CS_1^* \\ . \\ . \\ . \\ CS_8^* \end{bmatrix}_t + (I - M) \begin{bmatrix} CS_1 \\ . \\ . \\ . \\ CS_8 \end{bmatrix}_{t-1}$$

where

$$M = \begin{bmatrix} m_{11} & m_{12} & . & m_{18} \\ m_{21} & . & . & m_{28} \\ . & . & . & . \\ m_{81} & . & . & m_{88} \end{bmatrix} \qquad (4.30)$$

As in the other models, the 'other' input expense is dropped to avoid singularity. This eliminates the last row and column from the adjustment matrix. As the m_{ij} coefficients for the variable inputs are set to: m_{ii}=1 and m_{ij}=0 for i $\neq$j, and 'other' inputs are designated variable, there is no issue with the estimation of the M matrix. This matrix is assumed to be constant.

A necessary condition for this model is that the cost share equations must sum to one. This occurs when the changes in the cost shares across the nine inputs equals zero:

$$i(CS_t - CS_{t-1}) = iM(CS_t^* - CS_{t-1}) = 0 \qquad (4.31)$$

where i is the unit vector of dimension 1xn and M is the full n x n matrix. According the Berdnt and Savin, this equation is satisfied for autoregressive models if iM=zi, where z is an unknown constant. This occurs when one of the columns of the M matrix is set to zero. Therefore, the column for feed adjustments, m_{21},…m_{81} were set to zero (with m_{11}=1).

The cost shares for the dynamic model are estimated as:

$$CS_{i,t} = m_{ii}CS_{i,t}^* + (1 - m_{ii})CS_{i,t-1} + \sum_{j=1,i\neq j}^{4} m_{ij}(CS_{j,t} - CS_{j,t-1}) + \sum_{j=5,i\neq j}^{8} m_{ij}(CS^*{}_{j,t} - CS_{j,t-1}) \qquad (4.32)$$

Where CS_{it} and CS_{jt} are the observed cost shares in each period,

m_{ij} and m_{ji} are the adjustment coefficients to be estimated

CS_{it}^{*} and CS_{jt}^{*} are long-run optimal levels of the quasi-fixed factor shares (from the static model) and $CS_{i,t-1}$ and $CS_{j,t-1}$ are the observed cost shares from the preceding period.

As a result of the m_{ij} restrictions, the first four variable cost share equations are the same as the static model and the last four quasi-fixed cost shares contain the m_{ij} coefficients to be estimated.

The long-run elasticities are estimated from the same formula as the static model. The short-run Allen Uzawa elasticities of substitution are calculated as:

$$\sigma_{ij} = \frac{\sum_{k=1}^{n} m_{kj}\gamma_{jk} + CS_i CS_j}{CS_i CS_j} \qquad i, j = 1,\ldots,n \text{ but } i \neq j \qquad (4.33)$$

$$\sigma_{ii} = \frac{\sum_{k=1}^{n} m_{ik}\gamma_{ik} + CS_i^2 - CS_i}{CS_i^2} \qquad i = 1,\ldots,n \qquad (4.34)$$

The short-run price elasticities are calculated from the equation:

$$\varepsilon_{ij} = \frac{\sum_{k=1}^{n} m_{kj}\gamma_{jk} + CS_i CS_j}{CS_i} \qquad i, j = 1,\ldots,n \text{ but } i \neq j \qquad (4.35)$$

$$\varepsilon_{ii} = \frac{\sum_{k=1}^{n} m_{ik}\gamma_{ik} + CS_i^2 - CS_i}{CS_i} \qquad i = 1,\ldots, \text{n} \qquad (4.36)$$

These elasticities are interpreted as the first period response of factor demands to changes in factor prices.

4.5 Effectiveness of Farm Credit

The second portion of the thesis is using an econometric specification to examine the hypothesis: is the Farm Credit System effectively meeting its mandate to provide farmers with credit in economic downturns? As described in Chapter III, the effectiveness of the FCS will be evaluated by comparing the changes in lending between the FCS (FSA) and the CB sector. Using variables that are indicative of economic performance to capture the effects of the economy the following model is of the form:

$$CRL = \left(\frac{FC_t - FC_{t-1}}{FC_{t-1}}\right) - \left(\frac{CB_t - CB_{t-1}}{CB_{t-1}}\right) = \alpha_0 + \gamma_1 T + \beta_1 FarmIncome + \beta_2 GDP + \beta_3 Interest + \beta_4 Population + \beta_5 Failures + \beta_6 \varepsilon_{STcredit} + \beta_7 \varepsilon_{LTcredit} + \beta_8 \varepsilon_{Land} + e \quad (4.37)$$

Where, CRL= change in relative lending (for the FSA and FCS in real estate and non-real estate loans);

Farm Income= farm income (billions);

GDP= US real GDP;

Interest= US treasury yield;

Population= US farm population;

Failures= Number of farm bankruptcies in one year (000s);

$\varepsilon_{STcredit}$ = Short term weighted interest elasticity from the dynamic model;

$\varepsilon_{LTcredit}$ = Long term weighted interest elasticity from the dynamic model;

ε_{Land} = Land weighted interest elasticity from the dynamic model;

T= Time, and

$\alpha_0, \gamma_i, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ and β_8 are coefficients to be estimated.

The CRL variable is calculated as the percentage change in lending from the FCS (FSA) minus the percentage change in lending from the CB. Thus, in the regression results, when a coefficient is positive, it is reflecting an increase in the lending of FCS (FSA) comparatively to the CB. As well, when a coefficient is negative, it is reflecting a decrease in the lending of farm credit compared to CB. With respect to the long and short run elasticities in Chapter II, we show that the elasticities are sensitive to the absolute value of debt to assets, farm income, and interest rates. So our measure of elasticity may have certain collinearities with at least two of the variables in our regression in theory. However, because these elasticities were derived from the dual cost functions, a much more complex computation than what is outline in Chapter II this collinearity will be considerably diluted.

4.6 Summary

This chapter contained a description of the data and presented each of the models to be used in this study: the static model, the partial static model, the dynamic model, and the farm credit effectiveness model. The dual cost function model parameters will be based on state level data for the corn-belt states, looking at the expenditures for inputs and the values of the output. The parameters for the farm credit effectiveness model will be based on national data, apart from the state level elasticities. These variables were included to indicate macro economic changes that may affect the lending of the Farm Credit System.

Following the description of the data, the SUR model is discussed and analyzed. This model is incorporated as it mitigates the correlated standard errors associated with this research.

Subsequent to the SUR discussion, the equations to be estimated are analyzed. The Static, Partial Static, and Dynamic models begin with the nonhomothetic cost function which is nondecreasing in input prices and output from the restrictions set in Chapter III. The Static model is the most restrictive model, as it assumes all inputs are variable, where they adjust to the equilibrium value in each time period. The Partial Static model allows the quasi-fixed inputs to partially adjust in each time period and the variable inputs adjust completely in each period. The Dynamic model, allows the inputs to each adjust at their own appropriate rate to the equilibrium value in each period through the employment of an adjustment matrix. The equations for the elasticities of each of the models are presented following the model's discussion.

Finally, the Farm Credit System model is presented. This model looks to answer the question: is the Farm Credit System a relative countercyclical lender? In this section, we compare the changes in relative lending of the FCS and FSA to the CB by using macro-economic variables to capture the conditions of the markets.

The results from the four models presented in this chapter will be discussed in Chapters V and VI.

CHAPTER V

DUALITY RESULTS

5.0 Introduction

This chapter contains the results from the first portion of this thesis for the three dual cost models presented in earlier chapters. The following sections contain the parameter estimates from the three models, Static, Partial Static and Dynamic duality models, for each of the five states and the average, as well as the elasticity estimates for both the price and Allen-substitution evaluations. The Dynamic duality elasticities will be presented as both short-run and long-run values as discussed in Chapters III and IV.

The three models were included to more completely and effectively illustrate the differences between the dual models, which gave grounds for comparison. Each model was estimated as a SUR, discussed in Chapter IV, using the statistical software, Stata. As explained previously, SUR is a generalized least squares method where a set of nonlinear equations with cross-equation constraints are imposed and estimated with a diagonal covariance matrix of the standard errors across equations.

The results presented in this model are of the average of the states, thus giving and abstract and overview of the results. The individual states are presented in the Appendices as they give varying results. However, it should be states that the results from the individual states generally are larger and more significant than the average of the states.

5.1 Parameter estimates

The parameter estimates that will be presented for the Static, Partial Static, and Dynamic models for each of the states and the average of the states. Each state is analyzed separately in order to capture the changes between states. As a matter of efficiency, the results for the average of the five states will be presented in this chapter, and the remaining results for the individual states are in the respective appendices described below.

5.1.1 Static Model

The consolidated findings of the regression estimates for the static model by state are included in Table 5.1. This table includes the number of significant coefficients at the various levels.

Table 5.1: Static Model Consolidated Coefficient Results

	Static Model Coefficient Results					
	Illinois	Indiana	Iowa	Missouri	Ohio	Average
Number of coefficients significant at the 1% level	36	49	51	40	48	41
Number of coefficients significant at the 5% level	7	7	5	5	13	4
Number of coefficients significant at the 10% level	3	1	2	7	5	6
Number of coefficients not significantly different than zero	35	24	23	29	15	30
Total number of coefficients	81	81	81	81	81	81
Number of significant intercepts out of 8	7	6	7	7	4	5

As shown in the table, Indiana and Iowa had the most number of significant coefficients at the 1% significance level, however, Ohio had the lowest number of coefficients that were not statistically different than zero.

The results for the static model estimation for the average of the states is shown below in Table 5.2. The standard errors are included in parenthesis. The results for the static model for the individual states can be found in Appendices A.1, A.2, A.3, A.4, and A.5 for Illinois, Indiana, Iowa, Missouri, and Ohio, respectively. In order to obtain the values for the 'other inputs', they were derived from the symmetry and homogeneity restrictions imposed on the system, as described in Chapter IV. The coefficients on the inputs are symmetric between input price variables, thus only the bottom half of the price coefficient matrix is provided.

Table 5.2: Regression Estimates for the Static Model for the average of the five states

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.000663							
	(0.0140)							
s-t interest	-0.0325***	0.0456***						
	(0.00721)	(0.00690)						
wage	-0.0806***	-0.0392***	-0.108***					
	(0.0144)	(0.00965)	(0.0233)					
crop	0.0477***	0.00934	0.0178	-0.0921***				
	(0.0131)	(0.00773)	(0.0165)	(0.0285)				
livestock	-0.0411***	0.00636	-0.0166*	0.0796***	-0.00417			
	(0.00720)	(0.00471)	(0.00895)	(0.00916)	(0.00694)			
l-t interest	-0.0218***	0.0405***	0.0124	-0.0222***	0.0217***	-0.0245**		
	(0.00687)	(0.00587)	(0.00900)	(0.00642)	(0.00451)	(0.0104)		
land	0.00945**	0.00627*	0.0313***	-0.00255	-0.0130***	-0.00414	-0.0358***	
	(0.00399)	(0.00353)	(0.00536)	(0.00347)	(0.00243)	(0.00575)	(0.00766)	
machinery	-0.0844***	-0.0413***	-0.0130	0.0564***	-0.0183***	-0.0124*	0.0139***	-0.00582
	(0.0104)	(0.00627)	(0.0128)	(0.0187)	(0.00691)	(0.00672)	(0.00377)	(0.0160)
Output Quantity								
crops	-0.0314	-0.0284	0.00570	-0.00482	0.00848	0.0371	-0.0427	-0.00450
	(0.0313)	(0.0280)	(0.0442)	(0.0272)	(0.0197)	(0.0478)	(0.0647)	(0.0300)
livestock	0.0370	-0.170***	-0.160**	0.0901*	0.0230	-0.0131	0.355***	-0.125**
	(0.0554)	(0.0557)	(0.0771)	(0.0520)	(0.0364)	(0.0833)	(0.114)	(0.0524)
Time	-0.00170*	0.00390***	-0.00240*	-0.00220**	0.000961	0.00132	-0.00159	0.000200
	(0.00100)	(0.000970)	(0.00144)	(0.000939)	(0.000646)	(0.00149)	(0.00203)	(0.000949)
Intercept	3.558**	-6.996***	5.445**	4.127**	-2.050*	-2.508	2.077	0.311
	(1.721)	(1.657)	(2.474)	(1.638)	(1.110)	(2.537)	(3.449)	(1.635)
Observations	61	61	61	61	61	61	61	61
R-squared	0.922	0.754	0.797	0.927	0.857	0.218	0.494	0.849

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As seen above, there are many interesting significant coefficients from this model. Five of the eight intercepts were at significant least at the 10% level. The time trend shows to be less significant, with only four of the eight coefficient significant at the 10% level. It should also be noted from both Table 5.1 and the appendices, the states have varying significance for different inputs, which aligns with the explanation of differences in credit elasticities from Chapter II.

Generally, the cost share of an input decreases as the price of that input increases, as shown by the negative coefficient estimate along the diagonal of the symmetric price matrix. This suggests elastic demand of these inputs as the quantity decreases by more than the price increase. Specifically, long-term interest and land price shows a more elastic demand, which also supports the hypothesis of this research.

As the quantity of crops increases, all of the cost shares except Labor, Long-term credit, and Livestock have negative coefficients. However, it should be noted that these estimates are also not statistically different than zero. The quantity of livestock also intuitive results, as the cost shares for both feed and livestock increase with an increase in the quantity of livestock.

5.1.2 Partial Static Model

The consolidated findings of the Partial Static model by state are included in Table 5.3. This table includes the number of coefficients significant at the various levels. Dissimilar to the static model, the most statistically significant states in the partial static model are Missouri and Ohio, both of which have the most number of coefficient significant at the 1% level and the least amount of statistically insignificant coefficients.

Table 5.3 Consolidated Partial Static Model Coefficient findings for the States and average

	Partial Model Coefficient Results					
	Illinois	Indiana	Iowa	Missouri	Ohio	Average
Number of coefficients significant at the 1% level	15	16	17	19	19	18
Number of coefficients significant at the 5% level	2	2	2	6	1	5
Number of coefficients significant at the 10% level	3	2	1	2	3	1
Number of coefficients not significantly different than zero	24	24	24	17	21	20
Total number of coefficients	44	44	44	44	44	44
Number of significant intercepts out of 4	2	3	3	2	4	2

The parameter estimates for Illinois, Indiana, Iowa, Ohio, Missouri, and the average can be found in Appendices B.1, B.2, B.3, B.4, and B.5, respectively. As in the static models, the standard errors are included in parenthesis and each state is analyzed separately. Also, in order to obtain the values for the 'other inputs', they were derived from the symmetry and homogeneity restrictions imposed on the system, as described in Chapter IV. Once again, the coefficients on the inputs are symmetric between input price variables, thus only the bottom half of the price coefficient matrix is provided. The regression results from the Partial Static model for the average of the states is included in Table 5.4:

Table 5.4 Regression Estimates for the Partial Static Model for the average of the five states

Independent Variables	Feed	S-T credit	Labor	Crop
	Dependent Variables (Cost Shares)			
Input Price				
feed	-0.0164	-0.00301	-0.0164	0.0672***
	(0.0143)	(0.00679)	(0.0214)	(0.0185)
s-t interest	-0.00301	0.0349***	0.00434	0.0400***
	(0.00679)	(0.00543)	(0.00948)	(0.0106)
wage	-0.0490**	0.00434	0.0643**	0.124***
	(0.0214)	(0.00948)	(0.0284)	(0.0257)
crop	0.0672***	0.0400***	0.124***	-0.159***
	(0.0185)	(0.0106)	(0.0257)	(0.0415)
other	-0.171***	-0.0227	-0.108***	-0.289***
	(0.0252)	(0.0157)	(0.0356)	(0.0387)
Quasi-Fixed				
livestock	0.0907***	0.00163	0.0238	-0.0117
	(0.0111)	(0.00724)	(0.0157)	(0.0167)
l-t interest	0.0169**	0.0183***	-0.0344***	0.0734***
	(0.00834)	(0.00537)	(0.0119)	(0.0122)
land	0.00107	-0.00772***	-0.0259***	0.00987*
	(0.00357)	(0.00221)	(0.00500)	(0.00530)
machinery	-0.0321**	-0.0187**	-0.0492**	0.0823***
	(0.0149)	(0.00912)	(0.0214)	(0.0263)
Output Quantity				
crops	-0.0226	-0.00423	0.108***	-0.102**
	(0.0277)	(0.0176)	(0.0392)	(0.0408)
livestock	-0.124*	0.101**	0.178*	-0.339***
	(0.0738)	(0.0451)	(0.104)	(0.107)
Time	0.00435***	-0.00104	-0.000833	0.00583***
	(0.00151)	(0.000857)	(0.00211)	(0.00206)
Intercept	-7.584***	1.405	0.779	-9.401***
	(2.640)	(1.487)	(3.691)	(3.597)
Observations	62	62	62	62
R-squared	0.931	0.895	0.598	0.881

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As seen above, there again, are many interesting significant coefficients from this model. The intercepts were less significant in this model with only two of the four significant at the 1% level. The time trend is significant at the 1% level for two of the four cost shares as well. As in the static model, the states have varying significance for different inputs as can be seen from the appendices.

Feed and crop cost shares decreases as the price of that input increase. This suggests elastic demand of these inputs as the quantity decreases by more than the price increase. In the partial model, a very interesting result is the effect of the quantity of livestock on the cost shares. As the quantity of livestock increases, there is a significant result for each of the inputs. Specifically, the cost share for feed and crops decrease with increases of livestock, and the cost shares for short term credit and labor increase. This is counter-intuitive as we would expect that the cost share of feed would increase with an increase in quantity of livestock.

As the quantity of crops increases, all of the cost shares except Labor have negative coefficients. This is intuitive and aligns with the hypothesis of this research as we would expect the cost share of feed, short term credit, and crop inputs to decrease as the quantity of crops increases.

5.1.3 Dynamic Model

The consolidated findings of the Dynamic model by state are shown below in Table 5.5. This table, similar 5.1 and 5.3, includes the number of coefficients significant at the various levels. Seemingly as an average of the two models, the most statistically significant states were Iowa and Missouri with both having the most number of coefficient significant at the 1% level and the least amount of statistically insignificant coefficients. It should also be noted that the average is the least statistically significant regression, however, for efficiency, it will be the results discussed below.

Table 5.5 Consolidated Dynamic Model Coefficient findings for the States and average

	Dynamic Model Coefficient Results					
	Illinois	Indiana	Iowa	Missouri	Ohio	Average
Number of coefficients significant at the 1% level	22	22	38	29	26	17
Number of coefficients significant at the 5% level	3	8	4	8	4	14
Number of coefficients significant at the 10% level	3	3	5	8	4	3
Number of coefficients not significantly different than zero	53	48	34	36	47	47
Total number of coefficients	81	81	81	81	81	81

The regression results for the dynamic model coefficient estimates of the same parameters of the static model are shown in Appendices C.1, C.2, C.3, C.4, and C.5 for Illinois, Indiana, Iowa, Ohio, Missouri, and the average, respectively. The regression results for the average of the states will be presented below in Table 5.6. As in the past models, the standard errors are included in parenthesis. Also, in order to obtain the values for the 'other inputs', they were derived from the symmetry and homogeneity restrictions imposed on the system, as described in Chapter IV. Similar to the static model, the coefficients on the inputs are symmetric between input price variables, thus only the bottom half of the price coefficient matrix is provided.

Table 5.6 Regression Estimates for Dynamic Model for the average of the five states

Independent Variables	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
	Dependent Variables (Cost Shares)							
Input Price								
feed	0.186***							
	(0.0504)							
s-t interest	-0.0622	-0.532***						
	(0.0384)	(0.0897)						
wage	-0.00238	-0.490***	0.0257					
	(0.0361)	(0.0823)	(0.0317)					
crop	-0.0953	-0.00674	-0.0775**	0.622***				
	(0.0609)	(0.0406)	(0.0353)	(0.0676)				
livestock	0.0471*	0.469***	-0.0132	0.0540**	0.0356			
	(0.0270)	(0.0696)	(0.0321)	(0.0256)	(0.0236)			
l-t interest	-0.124**	0.00610	-0.0180	0.134***	0.00206	0.205***		
	(0.0523)	(0.0253)	(0.0226)	(0.0403)	(0.0184)	(0.0732)		
land	0.0688**	0.0586**	-0.00981	-0.0940***	-0.0522***	-0.0736**	0.0573*	
	(0.0302)	(0.0253)	(0.0211)	(0.0254)	(0.0139)	(0.0360)	(0.0328)	
machinery	-0.147***	0.00643	0.0105	-0.111***	-0.0379**	0.000249	-0.00118	0.0392
	(0.0475)	(0.0265)	(0.0348)	(0.0347)	(0.0188)	(0.0378)	(0.0221)	(0.0370)
Output Quantity								
crops	-0.0332	0.00145	0.0112	0.0106	0.0302**	0.0329	-0.0161	-0.0352
	(0.0435)	(0.0168)	(0.0149)	(0.0331)	(0.0140)	(0.0508)	(0.0412)	(0.0333)
livestock	-0.0284	-1.86e-05	0.000893	-0.00879	0.00832	0.0637***	-0.0383*	-0.00141
	(0.0203)	(0.00825)	(0.00755)	(0.0154)	(0.00694)	(0.0247)	(0.0203)	(0.0148)
Time	0.000411	2.05e-05	-0.000133	4.17e-05	-0.000591**	-0.00125	0.000605	0.000515
	(0.000703)	(0.000282)	(0.000263)	(0.000531)	(0.000231)	(0.000847)	(0.000699)	(0.000523)
Intercept	-0.540	-0.0314	0.208	-0.101	0.994**	2.071	-0.964	-0.860
	(1.196)	(0.477)	(0.455)	(0.901)	(0.391)	(1.433)	(1.182)	(0.886)
Observations	59	59	59	59	59	59	59	59
R-squared	0.302	0.266	0.407	0.585	0.503	0.260	0.129	0.020

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The intercepts were the least significant in this model with only one of the eight significant at the 5% level. The time trend is also very insignificant in the dynamic model, with only one of the eight cost shares showing significance. There are varying significances between inputs and cost shares in the different states which can be found in the discussed appendices.

Mostly, the cost share of an input increases as the price of that input increases, as indicated by a positive coefficient estimate along the diagonal of the symmetric price matrix in Table 5.6. This holds for every input except for short-term credit, which is interesting because it suggests there is an elastic demand for short term credit as the quantity decreases by more than the price increases.

An interesting result from this table is the positive significant coefficient on the increase of crop quantity on the cost share of livestock. We would expect that as crop quantity increases, the cost share for livestock would decrease, however this is not what is observed. A similarly unexpected result is the positive significant coefficient on the quantity of livestock on the cost share of long-term credit. This is one of the two significant coefficients for the quantity of livestock with the other being the cost share for land, which is intuitive.

Another set of perceptive coefficients are the positive relationships of the output of crops and the cost shares for both short and long-term credit. These suggest that as the quantity of crops increases, there is an increase in the cost share for both types of credit.

The adjustment matrices for the dynamic model are presented in Appendices D.1, D.2, D.3, D.4, and D.5 for Illinois, Indiana, Iowa, Missouri, and Ohio, respectively. These adjustment coefficients for the variable inputs were set to zero and one for cross and own adjustment coefficients respectively (the first four and the last rows). In order to satisfy the restrictions, set out in Chapter IV, the column for feed was set to zero. Twenty-eight coefficients were estimated for each state. The list of consolidated number of significant coefficients for each state are presented in Table 5.7

Table 5.7 Consolidated Dynamic Model Adjustment Coefficient findings for the States and average

	Dynamic Model Adjustment Matrix Coefficient Results					
	Illinois	Indiana	Iowa	Missouri	Ohio	Average
Number of coefficients significant at the 1% level	6	7	8	8	3	6
Number of coefficients significant at the 5% level	2	2	6	0	4	4
Number of coefficients significant at the 10% level	7	3	1	2	5	4
Number of coefficients not significantly different than zero	13	16	13	18	16	14
Total number of coefficients	28	28	28	28	28	28

Similar to the results from the Static and Dynamic models, Iowa and Missouri have the largest number of significant coefficients.

As described in Chapter IV, the adjustment coefficients determine the rate of adjustment toward the fully adjusted level for the cost shares. This adjustment matrix for the average of the states is presented below in Table 5.8. If m_{ii} is equal to zero, the inputs do not adjust to the equilibrium level. If m_{ii} is equal to one, the cost share completely adjusts in each period, which is assumed for the variable inputs. The adjustment coefficient for labor is the highest in each state, with Iowa having the highest adjustment of 87% each period. As described by Vanden Dungen (1992), these results are intuitive as by definition we would not expect a very long adjustment period for labor, especially in periods of high unemployment when there would be an abundance of labor.

Table 5.8 Regression Estimates for the Adjustment Matrix for the average of the states

Adjustment Coefficients

	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	0.00709	-0.0515***	0.0197	-0.0274**	-0.0386	0.0162	-0.0470*	0
		(0.0129)	(0.0125)	(0.0395)	(0.0139)	(0.0480)	(0.0395)	(0.0242)	
L-t Credit	0	0.0275	-0.0485***	0.110**	0.0353*	0.227***	-0.121**	0.0236	0
		(0.0184)	(0.0178)	(0.0562)	(0.0198)	(0.0682)	(0.0562)	(0.0344)	
Land	0	-0.0111	0.0122	-0.0306	-0.0230***	-0.0961***	0.0601**	-0.0267*	0
		(0.00816)	(0.00791)	(0.0250)	(0.00881)	(0.0303)	(0.0250)	(0.0153)	
Machinery	0	-0.000348	0.0570***	-0.0785*	0.0205	-0.0821	0.0651	0.0192	0
		(0.0155)	(0.0150)	(0.0474)	(0.0167)	(0.0575)	(0.0474)	(0.0290)	
Other	0	0	0	0	0	0	0	0	0

In this matrix, Table 5.8, the non-zero off diagonal coefficients reflect that input adjustments are not independent. The information on the effect on demand for input i given an adjustment in the demand for input j is shown in the coefficient m_{ij}. For example, when there is a discrepancy between the optimal and actual levels of machinery demanded (excess demand), the demand for long-term credit increases by 2.36% (m_{68}=0.0236). This implies that farmers are using long term credit to purchase machinery. An interesting coefficient in this matrix, is the positive adjustment for long-term credit and land. As m_{76} =0.0961, this suggests that when there is an excess demand for land, the demand for long-term credit increases by 9.6%. This suggests that there is evidence that there is overcapitalization in the agricultural sector.

5.2 Elasticity Estimates

The elasticity estimates are provided for the static, partial static, and dynamic models for each of the states as well as the average. Both the price and Allen-substitution elasticities are presented in these sections for each model and state. As the short-run price elasticities for land, short-term interest, and long-term interest are used in the model described in Chapter IV to analyze the effectiveness of the Farm Credit System, the main focus of this section will be the short-run dynamic elasticities.

5.2.1 Static Model Elasticities

The price elasticity estimates and Allen elasticities of substitution for the Static model of the average of the states are presented in Tables 5.9 and 5.10, respectively. The elasticity results for the price elasticities by state can be found in Appendices E.1, E.2, E.3, E.4, and E.5 for Illinois, Indiana, Iowa, Missouri, and Iowa respectively. The Allen-substitution estimates around also found in the appendix in F.1, F.2, F.3, F.4, and F.5 for the same respective states.

Table 5.9: Static Model Price Elasticity Estimates for the average of the states

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.84	-0.61	-0.50	0.41	-0.24	0.00	0.98	-0.49
ST credit	-0.19	0.11	-0.85	0.30	0.19	1.11	0.40	-0.89
Labor	-0.50	-0.85	-3.38	0.48	-0.34	0.14	0.95	-0.21
Crop	0.41	0.17	0.32	-2.29	1.22	-0.18	0.21	0.93
Livestock	-1.22	0.25	-0.50	2.75	-1.10	0.88	-0.19	-0.53
LT credit	0.01	0.31	0.14	-0.07	0.19	-6.94	0.22	0.00
Land	0.20	0.06	0.19	0.07	-0.02	0.13	-0.90	0.15
Machinery	-0.97	-0.51	-0.12	0.83	-0.20	-0.01	0.43	-0.99

As theory would suggest, the diagonal elements, showing the own price elasticity estimates, are mostly negative. This means that when the price of an input rises, the demand for that good should decrease, ceretis paribus. An interesting result from this table is the largely elastic effect of long-term credit on short-term credit. This suggests that when the price of long-term credit increases, the demand for short-term credit increases, reflecting a substitutionary relationship

According to Table 5.9, the short-term credit input is complementary with labor, feed, and machinery. For example, a 1% increase in the price of short-term credit causes a decrease of the demand for labor by 0.85% and feed by 0.61%. This follows intuition, as we would assume short-term credit would have a complementary relationship with the inputs as it is generally used to finance the purchase of these inputs.

Table 5.10 Static Model Allen Elasticity Estimates of Substitution for the average of the states

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	0.12							
ST credit	0.45	-37.66						
Labor	4.52	-2.08	-1.48					
Crop	-0.70	0.10	-2.07	0.57				
Livestock	-3.27	2.09	14.29	-7.06	8.78			
LT credit	5.35	23.14	1.48	5.09	1.85	-116.98		
Land	-0.88	0.08	-0.90	-1.27	-0.12	0.54	1.10	
Machinery	0.23	0.19	0.03	0.08	0.11	0.00	-0.05	-0.05

The Allen elasticity estimates presented in Table 5.10 measure the degree of substitutability or complementarity between inputs. As this matrix is symmetric, only the bottom half is presented. This table shows that short term credit and long term credit have a largely substitutionary relationship. It would appear that short-term credit has stronger relationships with the variable inputs than long-term credit, which is to be expected.

5.2.2 Partial Static Model Elasticities

The price elasticity estimates and Allen elasticities of substitution for the Partial Static model of the average of the states are presented in Tables 5.11 and 5.12, respectively. The elasticity results for the price elasticities by state can be found in Appendices G.1, G.2, G.3, G.4, and G.5 for Illinois, Indiana, Iowa, Missouri, and Iowa respectively. Following the structure of the static model, the Allen-substitution estimates around also found in the appendix in H.1, H.2, H.3, H.4, and H.5 for the respective states.

Table 5.11: Partial Static Model Price Elasticity Estimates for the average of the states

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-0.96	0.09	-0.06	0.55
ST credit	0.01	-0.14	0.16	1.03
Labor	-0.28	0.16	0.51	2.88
Crop	-1.09	1.03	1.90	-3.28

As we can see from this table, the elasticity for crop demand is the most elastic, with a 1% increase in the price of the crop inputs relating to a 3.28% decrease in the demand for the crop inputs. Another interesting point is the positive elasticity for labor which suggests that a 1% increase in the wage rate increases the demand for labor by 0.51%.

Table 5.12: Partial Static Model Allen Elasticity of Substitution Estimates for the average of the states

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-6.70			
ST credit	0.46	999.38		
Labor	-7.00	3.84	13.65	
Crop	-17.93	0.04	0.10	-55.87

The Allen elasticity estimates provided in the above table are provided for the restricted cost function model. Short-term credit has a large own price relationship of substitution, which is not was hypothesized. Overall, the partial static model did not perform as well as Static model in term of the expected estimated relationships.

5.2.3 Dynamic Model Elasticities

The elasticities for the dynamic model are calculated for both the short-run and the long-run. The difference, as shown in Chapter IV, the long-run estimates do not incorporate the adjustment coefficients in the calculations.

Long Run

Following the structure of the Static and Partial Static results, the long-run price elasticity estimates and Allen elasticities of substitution for the Dynamic model of the average of the states are presented in Tables 5.13 and 5.14, respectively. The elasticity results for the price elasticities by state can be found in Appendices K.1, K.2, K.3, K.4, and K.5 for Illinois, Indiana, Iowa, Missouri, and Iowa respectively. Following the price elasticities, the Allen-substitution estimates around also found in the appendix in L.1, L.2, L.3, L.4, and L.5 for the respective states.

Table 5.13: Dynamic Model Long-Run Price Elasticity Estimates for the average of the states

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	0.44	-1.31	0.04	-0.57	0.36	-0.70	0.72	-0.92
ST credit	-0.39	-13.55	-11.03	-0.08	11.13	0.30	1.63	0.24
Labor	0.04	-11.03	-0.36	-1.67	-0.26	-0.07	0.03	0.32
Crop	-0.57	-0.07	-1.10	8.33	0.84	2.14	-1.15	-1.56
Livestock	1.74	15.76	-0.39	1.89	0.23	0.22	-1.50	-1.18
LT credit	-0.68	0.08	-0.07	0.99	0.05	3.95	-0.25	0.09
Land	0.45	0.28	0.01	-0.31	-0.18	-0.16	-0.51	0.08
Machinery	-1.80	0.12	0.20	-1.39	-0.46	0.15	0.23	-0.39

The estimate for short-term credit indicates a very elastic demand, in which a 1% increase in the price of short-term interest rate would decrease the demand for short-term credit by 13.5%. A counter intuitive result for the long-term credit is also shown in this table. When the interest rate for long-term credit increases by 1%, there is an associated 3.95% increase in the demand for long-term credit. We can see that by treating the long-term credit as a quasi-fixed input, farmers are not as sensitive to long-run interest rates as in the static models. This shows that long-term credit is a highly inelastic input for agriculture.

In respect to cross-price elasticities, we see that short-term credit is complementary for feed, labor, and crop, and long-term credit is complementary for feed, labor, and land. For example, a 1% increase in the short-term interest rate would cause:

1) A 1.31% decrease in the demand for feed;
2) A 11.03% decrease in the demand for labor; and
3) A 0.07% decrease in the demand for crop inputs.

This is the relationship we would expect between variable inputs and short-term credit as it is often used to purchase these inputs.

The effect of long-term credit is also worth examining. For example, a 1% increase in the long-term interest rate would cause:

1) A 0.70% decrease in the demand for feed;
2) A 0.07% decrease in the demand for labor; and
3) A 0.16% decrease in the demand for land.

Just as the short-term credit is complementary with variable inputs, the long-term credit has the expected complementary relationship with the capital input of land. This is to be expected.

Table 5.14: Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for the average of the states

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	3.467							
ST credit	-0.015	-15602.155						
Labor	-14.561	-319.221	-7.495					
Crop	-9.550	-1.225	-26.805	150.456				
Livestock	10.695	487.048	-7.937	22.876	21.620			
LT credit	-4.684	1.848	-1.690	14.337	1.476	3.947		
Land	2.992	4.406	0.093	-5.050	-6.254	-1.147	-2.142	
Machinery	-11.890	3.481	4.178	-18.711	-17.478	1.022	0.938	-4.317

Following the results in Table 5.13, short-term credit has a complementary relationship with labor, crop and feed in Table 5.14. These results validate the importance of credit in the cost structure of the agricultural sector across the US cornbelt.

Short Run

Looking at the state results in Appendices I.1 and I.4 for Illinois and Missouri respectively, the state level elasticities are far more consistent with theory. This may suggest that the assumed convexity conditions, that is the imposition of symmetry by Roy's identity gets weaker as aggregation increases. In other words, convexity is much stronger at the local or state level and this should be taken into consideration when estimating duality models.

Finally, the results for the short-run Dynamic model follow the same structure as past models. These are the most critical elasticity estimates and the ones of most interest to economists. In addition, looking at Table 5.1.5, these estimates appear to be consistent in that all of the own-price effects are negative as theory predicts. The short run price elasticity estimates and Allen elasticities of substitution for the Dynamic model of the average of the states are presented in Tables 5.15 and 5.14, respectively. The elasticity results for the price elasticities by state can be found in Appendices I.1, I.2, I.3, I.4, and I.5 for Illinois, Indiana, Iowa, Missouri, and Iowa respectively. Following the price elasticities, the Allen-substitution estimates are also found in the appendix in J.1, J.2, J.3, J.4, and J.5 for the respective states.

Table 5.15: Dynamic Model Short-Run Price Elasticity Estimates for the average of the states

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.83	0.04	0.29	0.24	0.35	0.20	0.18	0.23
ST credit	0.03	-0.96	0.04	0.04	0.04	0.03	0.03	0.04
Labor	0.07	0.00	-0.90	0.08	0.12	0.07	0.04	0.08
Crop	0.02	-0.12	-0.11	-1.04	-0.20	0.03	0.05	-0.03
Livestock	0.05	0.06	0.06	0.05	-0.93	0.05	0.04	0.05
LT credit	0.15	0.14	-0.01	0.15	0.14	-0.85	0.15	0.15
Land	0.25	0.27	0.27	0.26	0.28	0.25	-0.75	0.26
Machinery	0.09	0.11	0.11	0.10	0.11	0.09	0.09	-0.90

Short term credit is complementary in the short run price elasticity with crop inputs. This occurs when a 1% increase in the cost of short term interest rates causes a 12% decrease in the demand for the crops inputs. This result is perceptive especially because farmers may delay leveraged purchases when they are experiencing a temporary rise in interest rates. In the short run farmers also appear to be equally sensitive to short-term interest rates an long-term interest rates, as they are fairly similar sizes of elasticities.

The elasticity for credit, both short and long term, varies by state as well. For example, in the short run, Iowa has the most complementary inputs with long term credit (Appendix I.2). It should also be noted that Illinois and Indiana show complementary relationships between short term credit and the variable inputs, as we would expect.

As we included the elasticities from the dynamic duality model in our Farm Credit model, described in Chapter VI, we also found the significance of the elasticities for the credit variables in the dynamic portion. After bootstrapping the sample to find the standard errors, we tested the credit elasticities at the 90%, 95%, and 99% significance levels. Of both the short and long term credit elasticities, Iowa, Ohio, and the Average of the states showed significance at the 90%, 95%, and 99% levels. The other states were not significant in either credit elasticity.

5.3 Summary

This chapter contained the estimation results for the duality portion of this thesis. It examined the regression results from the Static, Partial Static, and Dynamic models as well as the price and Allen substitution elasticities from each model. This chapter specially aimed to satisfy the first objective set out in Chapter I, by quantifying the relationship between short and long term credit and other inputs across the cornbelt states.

As the purpose of this portion of the thesis intended to answer the question of whether or not credit should be included as an input in the production process and whether credit has a complementary relationship with the other inputs. As in past literature, the results suggest that not only can credit enter the production process as an intangible input, but neglecting to include in the production function would create biased results.

Firstly, the results for the Static model are presented. These results showed the cost share of an input decreases as the price of that input increased, suggesting that these inputs had elastic demand for price. Specifically, the long and short term interest had elastic demands, which follows objective 2. The results for this model were strong for the average of the states, and even stronger for the individual states that are shown in the appendices.

Secondly, the Partial Static model is discussed. This model had slightly less impressive results with both time and the intercepts were less significant than the Static model. Feed and crop shares were the only inputs showing elastic demand, and interestingly, the coefficient for the short-term credit was both positive and significant at the 1% level, suggesting as the cost of credit increases the demand for credit increases as well.

Thirdly, the Dynamic model follows. This model showed less significance in the average of the states when compared to the individual states. However, the regression of the average of the states showed interesting results. For example, the Dynamic model suggests that when the quantity of crop output increases, the cost share for livestock increases as well, which is not what we would expect. This model also suggests that when the quantity of crops increase, there is an increase in the cost share for both types of credit.

Fourthly, the adjustment matrices for the Dynamic model are presented. Iowa showed the highest adjustment rate of 87% in each period while the average of the states was much lower, averaging about 5%. One of the compelling coefficients in this matrix was the positive adjustment between long-term credit and land, as it suggests that there is evidence of overcapitalization in the agricultural sector.

Fifthly, the elasticities for each model are presented including both the price and Allen-elasticities of substitution. Generally, across the models the short-term credit is more sensitive to the variable inputs, showing a complementary relationship. Similarly, the long-term credit is generally more sensitive to the fixed inputs, also exhibiting complementary relationships. This follow the hypothesis of credit demand we discuss in earlier chapters. Both the long-run and the short-run elasticities are presented for the Dynamic model. The short-run elasticities show stronger significance and follow intuition more than the long-run elasticities, as we expected. Due to the nature of short-run elasticities, we include these in the Farm Credit effectiveness portion in Chapter VI.

CHAPTER VI

FARM CREDIT RESULTS

6.1 Introduction

This chapter examines the results from the Farm Credit effectiveness portion of this thesis. First, the elasticities used from the Dynamic portion will be analyzed, followed by the regression results. The results are broken into the relative lending for the FCS and FSA in both real estate and non-real estate lending. In order to capture the differences of lending in different time periods, the regressions are broken in four categories: 1939-2013 with dummy variables for the years of World War II (1939-1945) and the farm crisis period (1970-1987), the years leading up to the farm crisis (1939-1969), the farm crisis period (1970-1987), and the years following the farm crisis (1988-2013). These results are calculated for the U.S. at the national level and are set out to complete the final objective described in Chapter 1.

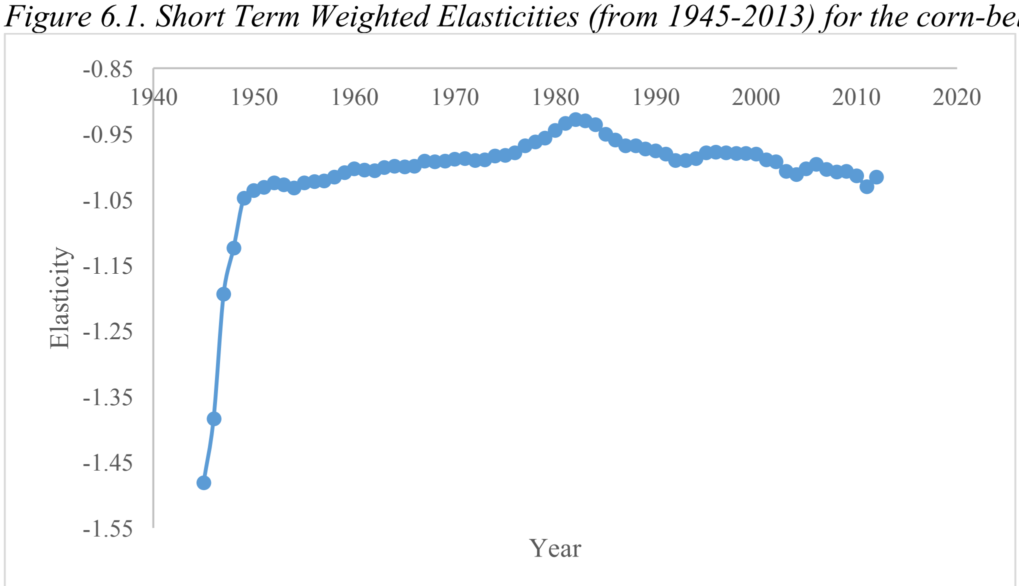
6.2 Elasticities

The elasticities used in the econometric specification for Farm Credit are obtained through the Dynamic Duality portion described in Chapter VI. These input elasticities are calculated for each of the five corn-belt states and then weighted by their state's respective input expense share. These weighted elasticities are summed; exhibiting the weighted average for the corn-belt region. These elasticities are included in this portion to attempt to give a numerical value to some behavioral aspects that would otherwise be left out. For example, the long term interest elasticity shows how sensitive farmers are to the interest rates they will receive on their real estate loans. Each elasticity is presented in absolute value so an increase means the elasticity value is becoming more elastic and a decrease in the value shows the elasticity is becoming more inelastic.

These elasticities are very important for understanding and interpreting the lending patterns between the FCS and FSA and CB. They give a numerical value to the sensitivity of farmers to changes in both interest rates and land prices; this is not captured in other variables in this model. By including these elasticities, we better understand how changes in the interest rates and land prices affect where farmers receive loans. For example, if the short-term weighted interest elasticity coefficient increases for FCS, this is interpreted as an increase in the elasticity of the interest rate (becoming more sensitive) suggests that the FCS would lend more relative to CB. Without these elasticities included in our model, we would not be able to explain how interest rates affect lending patterns.

As shown in Figure 6.1, the short-term weighted interest elasticity varies across the time period. This graph depicts the change in elasticity occurring around the farm crisis that is described in Chapter II.

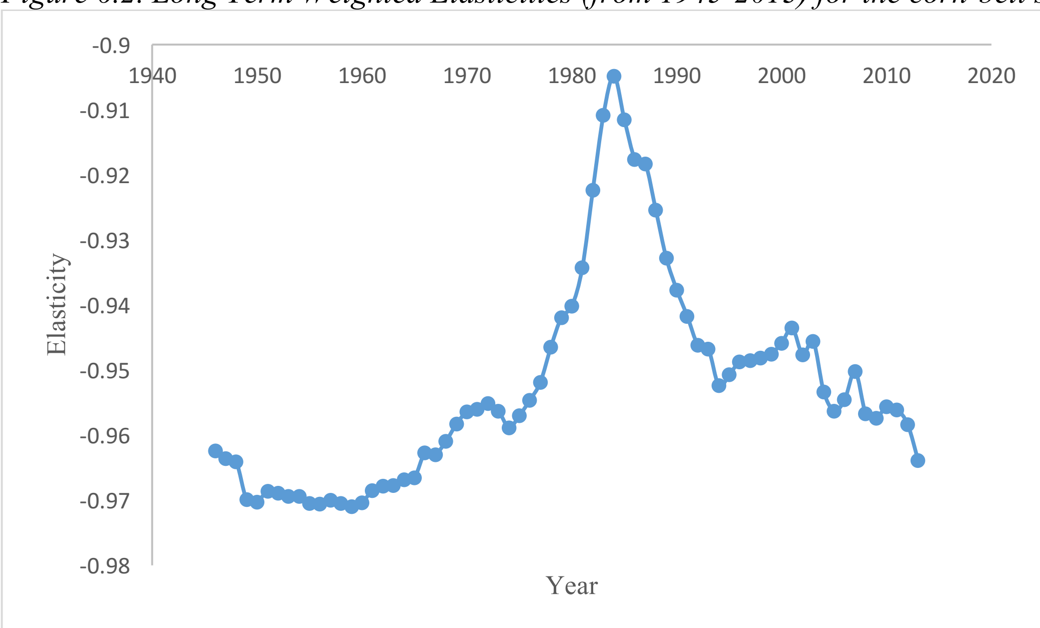
Figure 6.1. Short Term Weighted Elasticities (from 1945-2013) for the corn-belt states



In the years leading up to 1979, there is a decrease in the elasticity of interest rates. In other words, during this time period, farmers were the least sensitive to the interest rates on short term operating credit. However, following the beginning of the farm crisis in 1980, interest elasticities for short term credit become more elastic. In recent years the elasticities are becoming more stable than in the past.

Figure 6.2 shows the long term weighted interest elasticities for agriculture in the corn-belt states.

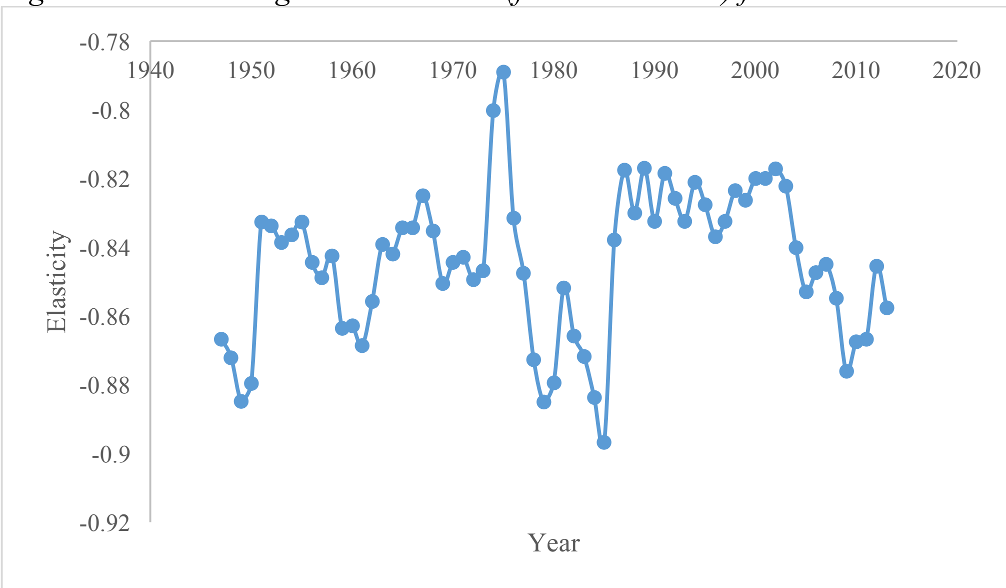
Figure 6.2. Long Term Weighted Elasticities (from 1945-2013) for the corn-belt states



Even though theory dictates that as the debt to asset ratio increases, the demand for credit becomes more elastic, Figure 6.2 shows that the actual change in elasticity is very small, going from approximately -0.97 to approximately-0.90 at the height of the financial crisis in 1982. The distinct portion of this graph is evident shortly after the farm crisis occurred. Around 1980, farmers were the least sensitive to the long term interest rates, however, immediately following the farm crisis was an increase in elasticity. As with short-term lending, there has been much less volatility since the crisis period.

The third elasticity included in this study is for the weighted land expense. It is shown in Figure 6.3:

Figure 6.3. Land Weighted Elasticities (from 1945-2013) for the corn-belt states



In this graph, the land price elasticity varies slightly from -0.75 to -0.9. Again, the most inelastic portion occurs in the years leading up to the farm crisis, and the most elastic values occur in the years following the farm crisis.

6.3 Farm Credit Effectiveness

The results from the reduced form Ordinary Least Squares (OLS) SUR regression are presented in this chapter. Each time period incorporates the variables described in Table 4.1 from Chapter VI. Each regression uses SUR to compare the relative lending of the FCS and FSA to CB for both real estate and non-real estate lending.

6.3.A The entire period

Table 6.1 shows the results of the regression for 1939-2013 including the dummies for the war and farm crisis years.

Table 6.1: Regression results for 1939-2013

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
1939-1945	-10.20	-23.39*	-5.004	-30.82***
	(8.463)	(13.33)	(7.795)	(11.06)
1970-1987	-5.472*	0.0943	3.626	-4.420
	(3.227)	(5.084)	(2.972)	(4.218)
Farm Income	3.87E-05	0.00023	-6.24E-05	-3.00E-06
	-0.000113	-0.000177	-0.000104	-0.000147
GDP	-0.718	0.45	0.174	0.164
	-0.813	-1.28	-0.749	-1.062
Interest	-1.337***	-1.11	-0.0962	0.816
	-0.491	-0.773	-0.452	-0.642
Population	-0.00117*	-0.00300***	6.90E-05	-1.14E-05
	-0.000611	-0.000963	-0.000563	-0.000799
Failures	-0.000243	-0.00985***	0.00385**	0.00254
	-0.00176	-0.00277	-0.00162	-0.0023
Number of Farms	0.00933	0.0293***	0.00016	0.000454
	-0.0057	-0.00898	-0.00525	-0.00745
ST interest elasticity	14.62	-16.08	1.525	30.05**
	-10.25	-16.15	-9.439	-13.4
LT interest elasticity	-739.8***	-1,256***	-53.67	211.2
	-137.6	-216.7	-126.7	-179.8
Land elasticity	29.62	-228.4***	-4.138	-158.0**
	-51.96	-81.87	-47.86	-67.92
Constant	660.3***	1,349***	46.7	-100.5
	-138.2	-217.7	-127.3	-180.6
Observations	73	73	73	73
R-squared	0.54	0.519	0.319	0.202

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this table, it shows that farm income is not a significant variable for either FCS or FSA lending, however the number of farm population is significant. When the number of famers increases by 1000 in a time period, we see a decrease in the relative lending for the FCS against the CB in real estate loans. The treasury yield is also significant in this section for FCS real estate lending at the 1% level. The negative coefficient attached to this variable suggest that when treasury yields increase, the CB system lends more in real estate loans relative to the FCS. The negative coefficient for the treasury yield is intuitive as the FCS is funded by bonds, which as treasury yields increase, would make the price of lending for FCS more expensive. For this time period, the long-term elasticities for interest are also significant for FCS and FSA real estate lending. When the long-term interest elasticity increases, we see a large decrease in FCS and FSA lending in real estate relative to the CB system. In this regression, the short-term interest elasticity has a less prominent effect on the relative lending. For FSA in non-real estate lending, the long term elasticity is positively significant at the 5% level, which suggests that when the long term interest becomes more elastic, FSA is lending relatively more.

6.3.B Before the Crisis: 1939-1969

Table 6.2 displays the regression results for the years leading up to the farm crisis.

Table 6.2: Regression results before the farm crisis: 1939-1969

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	0.00271**	-0.00543***	2.77e-05	-0.00129
	(0.00125)	(0.00170)	(0.00130)	(0.00101)
GDP	28.00***	4.432	29.29***	11.56
	(9.478)	(12.88)	(9.819)	(7.608)
Interest	1.929	-5.520	-11.68***	0.297
	(3.518)	(4.780)	(3.645)	(2.824)
Population	-0.000267	-0.00392**	-8.94e-05	-0.000307
	(0.00117)	(0.00159)	(0.00121)	(0.000938)
Failures	0.00794	-0.0187**	0.0133*	-0.0143***
	(0.00686)	(0.00932)	(0.00711)	(0.00551)
Number of Farms	0.0161	0.0544***	0.0208	0.0121
	(0.0134)	(0.0182)	(0.0139)	(0.0108)
ST interest elasticity	85.64***	-142.9***	-41.46*	6.176
	(24.32)	(33.05)	(25.20)	(19.52)
LT interest elasticity	3,116**	-6,162***	-2,227*	-622.3
	(1,262)	(1,715)	(1,307)	(1,013)
Land elasticity	127.6	38.66	51.72	0.661
	(92.83)	(126.1)	(96.17)	(74.52)
Constant	-3,425***	5,984***	2,011	526.6
	(1,259)	(1,711)	(1,304)	(1,011)
Observations	30	30	30	30
R-squared	0.768	0.771	0.488	0.661

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this table, the coefficient on Farm Income contradicts the hypothesis that the FCS provides countercyclical lending. In this time period, the coefficient on farm income suggests that there is not countercyclical lending from the FCS and it is positively significant at the 5% level for FCS. This suggests that when farm income increases, the FCS increases its lending compared to CB.

However, this hypothesis of countercyclical lending that was contradicted by the FCS lending in fact holds for the FSA, whose role was a lender of last resort. The coefficient for farm income on FSA is negatively significant at the 1% level, which suggests when the farm income increases, the FSA lends less in non-real estate relative to the CB. The short term elasticity measure is 1% significant for both the FCS and FSA for real estate lending, however, the FCS non-real estate lending is also positive in the opposite direction. The short-term elasticity measure is positive for real estate lending, suggesting when the price of interest is becoming more elastic, the FSA lends more relative to CB in real estate, however, the more interest becomes elastic, the less the FSA lends compared to CB. Table 6.3 also shows that when the interest rates for long term lending become more elastic by one, there is a 1% significance to the FCS lending increase relative to CB by three thousand percentage points. However, the more elastic long-term interest rates becomes, it shows a decrease in the lending from the FSA compared to CB.

6.3.C The Farm Crisis: 1970-1987

The results for the years of the farm credit results are reported in Table 6.3.

Table 6.3: Regression results for the farm crisis: 1970-1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	-0.000394**	-0.000213	-0.000392*	0.000747
	(0.000191)	(0.000370)	(0.000208)	(0.000672)
GDP	-29.87***	-34.64**	-32.63***	-6.390
	(7.227)	(14.03)	(7.877)	(25.47)
Interest	-1.233***	-0.0905	0.280	1.967
	(0.376)	(0.729)	(0.409)	(1.324)
Population	-0.104	0.283	-0.282***	0.131
	(0.0914)	(0.177)	(0.0997)	(0.322)
Failures	0.0154***	0.0170**	0.0155***	0.0158
	(0.00445)	(0.00865)	(0.00485)	(0.0157)
Number of Farms	0.0627	-0.534*	0.320**	-0.141
	(0.144)	(0.280)	(0.157)	(0.509)
ST interest elasticity	390.7	-930.5	1,042***	-539.7
	(365.1)	(708.8)	(398.0)	(1,287)
LT interest elasticity	-1,091*	1,207	-1,713***	1,615
	(558.0)	(1,083)	(608.2)	(1,967)
Land elasticity	31.21	168.1	-22.08	49.29
	(91.62)	(177.8)	(99.85)	(322.9)
Constant	805.6***	656.5	464.8*	-916.1
	(225.1)	(437.0)	(245.3)	(793.5)
Observations	18	18	18	18
R-squared	0.952	0.743	0.848	0.408

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Due to the low number of observations, it must be established that the results need to be treated with great caution. In order to be complete in the results, this time period must be included, however, making assumption based on these years is ill-advised. When the farm income increases in this time period, there is a decrease in the lending of FCS in both real estate and non-real estate (5% and 10% respectively). This supports the hypothesis of FCS lending in countercyclical business periods. During the crisis years, we see that the more farm failures that occurred, it was significantly associated to an increase in lending from the FCS and the FSA, which also supports the countercyclical lending hypothesis. The GDP follows a similar pattern; when the GDP is increasing (suggesting economic improvements) the FCS and FSA lend less relative to CB in real estate at 1% and 5% significance levels. When there is an increase in the short-term interest elasticity for non-real estate, it suggests an increase in FCS lending by over 1000 percentage points. Another considerable result of this regression is the 1% significance of long term interest elasticity. This result suggests that the FCS non-real estate lending decreases by more than a thousand percentage points when the long-term interest elasticity increases by 1.

6.3.D The years following the farm crisis: 1988-2013

Finally, Table 6.4 shows the results for the years following the farm credit crisis.

Table 6.4: Regression Results following the farm crisis 1988-2013

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	1.17e-05	2.01e-05	-4.27e-05	-0.000142*
	(0.000131)	(0.000191)	(8.89e-05)	(7.82e-05)
GDP	-6.418**	-2.644	2.180	1.098
	(3.047)	(4.463)	(2.072)	(1.824)
Interest	-0.193	-0.0447	-1.294**	0.558
	(0.912)	(1.335)	(0.620)	(0.546)
Population	0.0641	0.0746	-0.0342	-0.0267
	(0.0529)	(0.0774)	(0.0360)	(0.0317)
Failures	0.0122**	0.00722	-0.00168	-0.00158
	(0.00567)	(0.00830)	(0.00385)	(0.00339)
Number of Farms	0.0760	0.0206	-0.0423	-0.0236
	(0.0539)	(0.0790)	(0.0367)	(0.0323)
ST interest elasticity	-360.2	-18.39	31.34	741.9***
	(365.6)	(535.4)	(248.6)	(218.8)
LT interest elasticity	1,510*	728.4	-666.7	-933.2*
	(835.6)	(1,224)	(568.2)	(500.2)
Land elasticity	-6.595	-353.8	-21.67	-264.1**
	(195.6)	(286.5)	(133.0)	(117.1)
Constant	-1,228*	-465.6	725.6	450.3
	(667.7)	(977.9)	(454.1)	(399.7)
Observations	25	25	25	25
R-squared	0.423	0.361	0.277	0.570

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

In these results we do not find evidence of a countercyclical role for FCS or FSA, but the general trend during this entire period shows both increasing farm income and steady treasury yield rates. Due to the consistency of the past years it is unclear if this is an appropriate period to test the hypothesis for FCS lending counter cyclically. There is only weak evidence to suggest that the FCS has a countercyclical lending role.

As the coefficient on short-term non-real estate lending for FSA suggests (at 1% significance), when farmers become more sensitive to interest expenses, they move towards FSA lending and away from CB, which suggests countercyclical lending. In these results, the land elasticity also has a 5% significance in non-real estate lending for FSA. This suggests that when land price elasticity increases by 1 (becoming more elastic) the FSA decreases its lending by 264 percentage points relative to CB.

6.4 Alternative Measures and Robustness Checks

In order to test alternative relationships and possible contradictions we also ran a number of additional regressions with a similar independent variable structure but with alternative dependent variables. These dependent variables included: the absolute value of lending, the share of lending, and the change in lending from the previous time period for each of the entities. As in the changes in relative lending regressions, the estimates are broken into sections to reflect the time period. The regressions that show the value of lending for 1939-2013, 1939-1969, 1970-1987, and 1988-203 can be found in Appendices N.1, N.2, N.3, and N.4, respectively. The regression estimates for the share of lending for the same time periods can be found in O.1, O.2, O.3, and O.4, respectively. Finally, the regression estimates for the change of lending between years are also broken into the previous time periods and can be found in Appendices P.1, P.2, P.3, and P.4, respectively.

In each of these robustness checks we found nothing to contradict the story presented in this chapter. For example, in Appendix P.2 the changes in relative lending leading up to the farm crisis shows similar results as the changes in relative lending for 1939-1969, shown in Table 6.3.B. In both results, the short-term interest elasticity is positive and significant at the 1% level for real estate loans from the FCS. Another example is shown in Appendix N.4, the absolute value of lending for the years after the farm crisis shows similar results to the changes in relative lending for 1988-2013, shown in Table 6.5. Specifically, the long-term interest rate is positively significant at the 10% level for both results in real estate debt of the FCS.

6.5 Summary

This chapter examines the results found in the Farm Credit portion of this thesis by aiming to achieve objective 3 set out in Chapter 1. As described above, many factors suggest that the Farm Credit system is lending countercyclical to the economy. This would support the hypothesis that they are meeting their mandate to provide credit for farmers during economic downturns.

First, a discussion of the elasticities taken from the Dynamic model described in earlier chapters is presented. We explain that the long-term interest elasticities shows how sensitive farmers are to the interest rates they will receive on their real estate loans and the short-term interest elasticities explain the same relationship with operating credit interest rates.

Secondly, the results from the reduce form OLS SUR regression model are presented. These results are broken into specific time periods in order to capture the economic changes that occurred during the farm crisis, and examine the lending patterns, before, during, and after the crisis. The changes in relative lending for the entire period generally suggest that the FCS and FSA are lending countercyclically. For example, when the number of farm failures increases, the FCS lends more relative to the CB in real estate loans. The elasticities from the Dynamic model are also shown to be significant, particularly, when the short-term interest elasticity becomes more elastic, the CB lends more relatively. The results from the changes in relative lending in the years leading up to the crisis show similar patterns. The short-term interest rate elasticity displays the same effect as described above, and when the long-term elasticities become more elastic, the FCS increases their lending relative to the CB. The years of the farm credit crisis and the years following the crisis need to be interpreted with caution as described in the sections. The changes in relative lending for the crisis years, need to be taken with caution due to the low number of observations. Similarly, in the years following the crisis, the changes in relative lending do not show the same significance as the entire time period nor the years leading up to the crisis, perhaps due to the stability of the market and consistently low interest rates.

Generally, in each time period we see evidence of countercyclical lending by the FCS and the FSA compared to the CB, which is what we aimed to achieve in Objective 3.

CHAPTER VII

SUMMARY AND CONCLUSIONS

7.1 Introduction

This study aimed to estimate the demand for credit and its relationships with other inputs as well as estimating the effectiveness of the Farm Credit System in the US. In order to estimate the demand for credit, a dual cost function approach was used to estimate its relationships with agricultural inputs. Our estimates for the three models, Static model, Partial Static model, and Dynamic model, are based on pooled data from five US corn-belt states; Illinois, Indiana, Iowa, Missouri, and Ohio. These estimates were then used to calculate both the price and Allen-elasticities of substitution for each input in each model. To analyze the effectiveness and success of the Farm Credit System, we created an econometric specification that incorporated both macro-economic indicative variables, but three of the elasticities from the Dynamic model described earlier.

This chapter will summarize and conclude this study and is organized as follows. Firstly, the motivation for this study and its objectives will be presented. Second, a summarized description of the findings of this thesis will be presented. This will be followed by the suggestions for future research and the contributions of this research to the field of agricultural economics.

7.2 Motivation for study

Despite being an essential portion of the production process, credit is generally left out of production functions. The interest rates are a nontrivial portion of the costs to farmers, but little literature is available which discusses their impacts in production functions for agriculture. As farm debt levels rose in the years leading up to the farm credit crisis and the interest rates increasing into the 1980's, credit became one of the more dominant input costs for farmers. Due to the increase in technology and movement towards capitalization, credit is an essential input for farmers. However, it is not only the cost of credit, but its availability to farmers is also a contentious issue in agriculture. Following the backlash from the American Bankers Association, the system of Farm Credit developed in the 1930's, is and always has been, a hot button topic in agriculture. There is much debate about the effectiveness and necessity of the FCS in congress, as it has not been shown explicitly that it has met the goals and objectives set out in 1934. If credit availability and cost is indeed a great concern for farmers, then the effectiveness of the FCS and the cost of credit, would change the traditional results of a production function that omit credit as an input.

Thus this study was driven by the following issues

1. credit should not be omitted as an input for the production process of agriculture as it is an important cost;
2. the implications of excluding credit in supply/demand analysis;
3. the availability of credit from the FCS and CB to farmers; and
4. the usefulness and value the FCS brings to US agriculture.

Hence this thesis aims to resolve this neglect by addressing each of the issues in the objectives described below.

7.3 Objectives and Findings

The overall purpose of this thesis is to estimate credit demand elasticities and their relationship between Commercial and Farm Credit System lending. We achieve this by following and completing the following objectives:

1) Determine and identify the relationship between interest rates and credit demand;

Findings: The first objective was satisfied by obtaining the estimates for the three models, the Static model, the Partial Static model, and the Dynamic model. Firstly, the results for the Static model showed the cost share of an input decreases as the price of that input increased, suggesting that these inputs had elastic demand for price. Specifically, the long and short term interest had elastic demands, which follows objective 2. The results for this model showed significance for the average of the states, and even significance for the individual states that are shown in the appendices.

Secondly, the Partial Static model had slightly less impressive results with both time and the intercepts were less statistically significant than the Static model. Feed and crop shares were the only inputs showing elastic demand, and interestingly, the coefficient for the short-term credit was both positive and significant at the 1% level, suggesting as the cost of credit increases the demand for credit increases as well. This proposes that credit is an inelastic demand in agriculture.

Thirdly, the Dynamic model showed less statistical significance in the average of the states when compared to the individual states. However, the regression of the average of the states showed interesting results. For example, the Dynamic model suggests that when the quantity of crop output increases, the cost share for livestock increases as well, which is not what we would expect. This model also suggests that when the quantity of crops increase, there is an increase in the cost share for both types of credit, meaning when output is increased it is also associated to an increase in the cost of the credit.

Finally, the adjustment matrices for the Dynamic model were estimated. The state of Iowa had the highest adjustment rate of 87% in each period while the average of the states was much lower, averaging about 5%. One of the compelling coefficients in this matrix was the positive adjustment between long-term credit and land, as it suggests that there is evidence of overcapitalization in the agricultural sector.

2) To develop measures for the interest rate elasticity in a production function from duality principles;

Findings: The second objective was satisfied by obtaining the price and Allen-elasticities of substitution for the three models. Generally, across the models the short-term credit is more sensitive to the variable inputs, showing a complementary relationship. Similarly, long-term credit is generally more sensitive to fixed inputs and also exhibits complementary relationships with fixed inputs. As both the long-run and the short-run elasticities are presented for the Dynamic model, the short-run elasticities showed stronger statistical significance than the long-run elasticities, as we expected

3) To investigate the differential roles that the Farm Credit System and Commercial Banking sectors have on the supply and demand of agricultural credit in the US;

Findings: The third and final objective was to investigate the differential roles that the FCS and CB sectors have on the supply and demand of US agricultural credit. The changes in relative lending for the entire period generally suggest that the FCS and FSA are lending countercyclically. For example, when the number of farm failures increases, the FCS lends more relative to the CB in real estate loans. The elasticities from the Dynamic model are also shown to be significant, particularly, when the short-term interest elasticity becomes more elastic, the CB lends more relatively. The results from the changes in relative lending in the years leading up to the crisis show similar patterns. The short-term interest rate elasticity displays the same effect as described above, and when the long-term elasticities become more elastic, the FCS increases their lending relative to the CB In the years following the crisis, which can be characterized by low and stable interest rates, there was weaker evidence suggesting countercyclical lending. However, generally in each time period we see some evidence of countercyclical lending by the FCS and the FSA compared to the CB, which is what we aimed to achieve.

7.4 Suggestions for future research

Due to the unique nature of this study, a variety of future research should be conducted on this topic to confirm or contradict these findings. For example, similar research might be done in other areas of US agriculture outside of the cornbelt, or even in other countries. It would also be interesting to examine this research topic using less aggregated data to examine the effects of county or even individual level, data. With a larger number of observations, this would likely improve the results in terms of confidence. Another interesting application of this study would be to examine the availability and cost of credit in developing countries. As the US has policies and legal systems in place to protect the world of credit, it would be noteworthy to examine these models in areas of the world where credit is much more expensive and risky to obtain.

7.5 Contributions of this research

This study is unique in that it is the first of its kind in almost 20 years. As some research has been done in the past to include credit as an input and use a dynamic model, this is the first study to examine the cost of credit to farmers are the state level. Our results show that credit is in fact, an important input for production, and its cost, interest rate, is not a trivial cost. This study also contributes to the related literature by providing an examination of the effectiveness of the FCS. Our results suggest that the FCS has been a countercyclical lender in agriculture, particularly in times of volatile interest rates. This study, with the intention of examining the effectiveness of the FCS, illustrates that although in times of stable and low interest rates the FCS does not show strong signs of countercyclical lending, during the more volatile interest rate periods, the FCS seemed to perform its role as a countercyclical lender. Perhaps though, one attribute of the FCS and FSA that cannot be quantified in a regression table is described by Kanbur, as he states on the matter of Laissez Faire, "*the important thing for government is not to do things which individuals are doing already, and to do them a little better or a little worse; but to do those things at present are not done at all*" (page 291, cf Kanbur 2015).

REFERENCES

Baker, CB. “Credit in the production organization of the firm.”
American Journal of Agricultural Economics (1968): 507-520

Beattie, B.R., and C.R. Taylor.
The Economics of Production, John Wiley and Sons. (1985).

Berndt, E.R., Morrison, C.J., and Campbell Watkins. “Dynamic Models of Energy Demand: An Assessment and Comparison”
Measuring and Modelling Natural Resource Subsitution, MIT Press. (1981).

Bogan, Vicki L., Turvey, Calum G., and Gabriela Salazar. “The Elasticity of Demand for Microcredit: Evidence from Latin America.”
*Development Policy Review.*33. (2015):725-757

Greene, William H. "Systems of Regression Estimates."
Econometric Analysis. 5th ed. (2003): 339-360.

Johnston, J. "Generalized Least Squares."
Econometric Methods. 3rd ed. (1984): 337-340.

Kanbur, Ravi. “The End of Laissez-Faire, The End of History, and The Structure of Scientific Revolutions.”
Working Paper. (2015)

O’Hara, M. “Tax-Exempt Financing: Some Lessons from History.”
Journal of Money, Credit and Banking. (1983): 425-441.

Putnam, G.E. “The Federal Farm Loan System.”
American Economic Review. (1919): 57-78.

Shee, Apurba, and Calum G. Turvey. "Collateral-free Lending with Risk-contingent Credit for Agricultural Development: Indemnifying Loans against Pulse Crop Price Risk in India."
Agricultural Economics 43.5 (2012): 561-74.

Smith, Bruce D., and Michael J. Strutzer. “Adverse Selection and Mutuality: The Case of the Farm Credit System.”
Journal of Financial Intermediation, 1 (1990): 125-149.

Tsigasm M.F. and T.W. Hertel. “Testing Dynamic Models of the Farm Firm.”
Western Journal of Agricultural Economics, 14 (1989): 20-29.

Thompson, C.W. “The Federal Farm Loan Act.”
American Economic Review. (1917): 115-131.

Turvey, Calum G. “A Brief History of the U.S. Farm Credit System.”
International Conference of Agricultural and Rural Development, (2006) 2-29.

Turvey, Calum G. “Historical Development in Agricultural Finance.”
(2015): 1-36.

USDA, ERS. “Economic Indicators of the Farm Sector: State Financial Summary,” various editions.

Vanden Dungen, Marcel J. “Estimating the Demand for Farm Operating and Term Credit: a Dynamic Approach.”
Thesis for The University of Guelph. (1992): 1:115.

Weeksink, Alfons, Marcel J. Vanden Dungen, and Calum G. Turvey. "Estimating the Demand for Farm Operating and Term Credit."
Cahiers D'economie Et Sociologie Rurales 33.4 (1994): 93-116.

United States Department of Agriculture. “FAQs.”
Farm Credit FAQ. (2015).

United States Department of Agriculture. “U.S Department of Agriculture.”
U.S. Department of Agriculture. (2015).

APPENDICIES

Appendix A.1 Regression Estimates for the Static Model for Illinois

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	-0.0208							
	(0.0173)							
s-t interest	-0.0384***	0.0432***						
	(0.00716)	(0.00628)						
wage	-0.111***	-0.0527***	-0.132***					
	(0.0130)	(0.00738)	(0.0173)					
crop	-0.0457***	0.00635	-0.0188	0.131***				
	(0.0150)	(0.00757)	(0.0161)	(0.0288)				
livestock	0.0141	0.0123**	0.0271***	-0.0105	0.0594***			
	(0.0100)	(0.00579)	(0.00953)	(0.0111)	(0.0113)			
l-t interest	-0.0230***	0.00758**	-0.00868	-0.00495	-0.0175***	0.0122***		
	(0.00613)	(0.00346)	(0.00591)	(0.00690)	(0.00508)	(0.00415)		
land	0.00417	-0.000958	0.0110***	0.00903**	0.00100	-0.00754***	-0.0108*	
	(0.00437)	(0.00344)	(0.00409)	(0.00388)	(0.00349)	(0.00224)	(0.00638)	
machinery	0.0745***	0.0715***	0.0932***	-0.0828***	0.0131	0.0330***	0.000269	0.0264
	(0.0131)	(0.00758)	(0.0129)	(0.0179)	(0.0101)	(0.00643)	(0.00488)	(0.0185)
Output Quantity								
crops	0.00365	-0.00199	0.0102*	0.0144***	-0.00406	0.00103	-0.00912	-0.00419
	(0.00607)	(0.00512)	(0.00596)	(0.00535)	(0.00487)	(0.00321)	(0.00957)	(0.00692)
livestock	-0.0230	0.0448***	-0.0532***	-0.00155	0.00293	0.0170*	-0.00288	0.0399**
	(0.0173)	(0.0142)	(0.0168)	(0.0155)	(0.0140)	(0.00950)	(0.0261)	(0.0197)
Time	-0.00404***	0.000260	-0.00435***	0.00377***	-0.00169***	0.000465*	0.00122*	2.25e-05
	(0.000516)	(0.000396)	(0.000538)	(0.000558)	(0.000405)	(0.000263)	(0.000720)	(0.000575)
Intercept	8.476***	-1.119	9.352***	-7.474***	3.475***	-1.162**	-2.004*	-0.454
	(0.915)	(0.688)	(0.971)	(1.030)	(0.716)	(0.460)	(1.218)	(1.012)
Observations	62	62	62	62	62	62	62	62
R-squared	0.915	0.458	0.867	0.963	0.931	0.886	0.107	0.847

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A.2 Regression Estimates for the Static Model for Indiana

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0197							
	(0.0179)							
s-t interest	-0.0357***	0.0401***						
	(0.00771)	(0.00734)						
wage	-0.0725***	-0.0397***	-0.187***					
	(0.0154)	(0.00996)	(0.0249)					
crop	-0.00881	0.00729	0.00164	0.0867***				
	(0.0135)	(0.00771)	(0.0173)	(0.0260)				
livestock	-0.0152*	-0.00618	-0.0131	-0.00527	0.0259***			
	(0.00894)	(0.00507)	(0.0106)	(0.00928)	(0.00906)			
l-t interest	-0.0293***	0.0187***	-0.0111	-0.0196***	-0.0137***	0.0225***		
	(0.00614)	(0.00345)	(0.00697)	(0.00656)	(0.00410)	(0.00373)		
land	0.000726	0.000395	0.0140***	0.00702*	0.00361	-0.00549***	-0.0164***	
	(0.00465)	(0.00371)	(0.00480)	(0.00362)	(0.00272)	(0.00201)	(0.00541)	
machinery	0.0631***	0.0801***	0.117***	-0.0706***	0.0239***	0.0296***	-0.00267	0.0240
	(0.0135)	(0.00882)	(0.0156)	(0.0168)	(0.00866)	(0.00611)	(0.00544)	(0.0206)
Output Quantity								
crops	0.00769	0.0178	0.0146	0.0573***	-0.0134	-0.00390	-0.0182	0.00585
	(0.0136)	(0.0114)	(0.0154)	(0.0115)	(0.00846)	(0.00643)	(0.0156)	(0.0164)
livestock	0.00747	0.0119	-0.0424*	-0.0450***	0.0220*	0.0270***	-0.0455*	0.00951
	(0.0204)	(0.0187)	(0.0228)	(0.0162)	(0.0120)	(0.00896)	(0.0247)	(0.0252)
Time	-0.00370***	-0.00101*	-0.00376***	0.00189***	-0.00151***	0.000230	0.00361***	-0.000170
	(0.000754)	(0.000575)	(0.000889)	(0.000726)	(0.000448)	(0.000332)	(0.000813)	(0.000851)
Intercept	7.373***	1.561	7.960***	-3.705***	2.959***	-0.797	-6.073***	0.243
	(1.405)	(1.054)	(1.667)	(1.367)	(0.833)	(0.614)	(1.458)	(1.563)
Observations	62	62	62	62	62	62	62	62
R-squared	0.893	0.501	0.840	0.956	0.888	0.904	0.368	0.858

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix A.3 Regression Estimates for the Static Model for Iowa

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0552***							
	(0.0170)							
s-t interest	-0.0281***	0.0456***						
	(0.00768)	(0.00696)						
wage	-0.0890***	-0.0551***	-0.160***					
	(0.0152)	(0.00944)	(0.0248)					
crop	-0.0415***	0.00404	-0.0499***	0.101***				
	(0.0133)	(0.00746)	(0.0193)	(0.0307)				
livestock	0.0334***	0.0390***	0.0431***	-0.0207*	0.121***			
	(0.0123)	(0.00819)	(0.0137)	(0.0110)	(0.0182)			
l-t interest	-0.0346***	0.0179***	-0.0188***	0.00476	0.000697	0.0131***		
	(0.00514)	(0.00322)	(0.00634)	(0.00661)	(0.00539)	(0.00308)		
land	-0.00130	-0.0107***	0.0106**	0.00868***	-0.000362	-0.00910***	-0.0107**	
	(0.00530)	(0.00380)	(0.00497)	(0.00335)	(0.00612)	(0.00215)	(0.00485)	
machinery	0.0482***	0.0348***	0.105***	-0.0546***	-0.0663***	0.0198***	0.00462	0.0656***
	(0.0127)	(0.00768)	(0.0153)	(0.0179)	(0.0121)	(0.00515)	(0.00448)	(0.0177)
Output Quantity								
crops	0.0238*	0.0116	0.0306**	0.0288***	-0.0519***	0.00361	0.0138	-0.0114
	(0.0123)	(0.00992)	(0.0127)	(0.00850)	(0.0148)	(0.00543)	(0.0110)	(0.0108)
livestock	-0.0398	0.0130	-0.0486**	-0.0239	0.0309	0.00895	-0.0595***	0.0755***
	(0.0243)	(0.0199)	(0.0245)	(0.0156)	(0.0293)	(0.0106)	(0.0224)	(0.0214)
Time	-0.00188**	0.000913	-0.00469***	0.00158**	0.00279***	0.000598*	0.00129*	-0.00330***
	(0.000815)	(0.000598)	(0.000941)	(0.000803)	(0.000887)	(0.000356)	(0.000697)	(0.000753)
Intercept	4.265***	-2.199**	9.727***	-3.078**	-5.143***	-1.367**	-1.655	5.677***
	(1.461)	(1.061)	(1.718)	(1.499)	(1.567)	(0.636)	(1.225)	(1.355)
Observations	62	62	62	62	62	62	62	62
R-squared	0.827	0.615	0.854	0.954	0.812	0.827	0.240	0.836

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix A.4 Regression Estimates for the Static Model for Missouri

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0356							
	(0.0233)							
s-t interest	-0.0162*	0.0432***						
	(0.00913)	(0.00738)						
wage	-0.0660***	-0.0297***	-0.127***					
	(0.0154)	(0.00837)	(0.0200)					
crop	0.0153	0.0163**	-0.0661***	0.132***				
	(0.0133)	(0.00726)	(0.0145)	(0.0242)				
livestock	-0.0116	0.00408	-0.00577	0.00163	0.0777***			
	(0.0100)	(0.00531)	(0.00889)	(0.00842)	(0.00802)			
l-t interest	-0.0118*	0.0254***	-0.0182***	0.00462	-0.0171***	0.0166***		
	(0.00668)	(0.00353)	(0.00587)	(0.00537)	(0.00379)	(0.00338)		
land	-0.000922	-0.00912***	0.0213***	-0.00289	0.0144***	-0.0112***	-0.0201***	
	(0.00549)	(0.00297)	(0.00391)	(0.00319)	(0.00261)	(0.00207)	(0.00307)	
machinery	0.0375**	0.0400***	0.0862***	-0.104***	0.00348	0.0349***	-0.00990**	0.0567***
	(0.0162)	(0.00885)	(0.0137)	(0.0152)	(0.00918)	(0.00559)	(0.00467)	(0.0198)
Output Quantity								
crops	0.0658	0.0188	0.0508	-0.0159	-0.0426*	0.0447**	-0.0324	-0.134***
	(0.0452)	(0.0283)	(0.0366)	(0.0271)	(0.0233)	(0.0193)	(0.0297)	(0.0446)
livestock	0.153*	-0.0681	-0.210***	0.0300	-0.185***	-0.0632*	0.348***	0.104
	(0.0853)	(0.0593)	(0.0679)	(0.0528)	(0.0456)	(0.0353)	(0.0520)	(0.0871)
Time	-0.00501***	0.00195*	-0.00256**	0.00446***	0.00149*	0.00141**	-0.00190**	0.00130
	(0.00148)	(0.00103)	(0.00124)	(0.000968)	(0.000797)	(0.000638)	(0.000956)	(0.00155)
Intercept	9.222***	-3.687**	5.897***	-8.797***	-1.885	-2.706**	2.563	-2.302
	(2.531)	(1.769)	(2.151)	(1.682)	(1.366)	(1.091)	(1.631)	(2.656)
Observations	62	62	62	62	62	62	62	62
R-squared	0.754	0.723	0.880	0.921	0.906	0.876	0.614	0.739

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix A.5 Regression Estimates for the Static Model for Ohio

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0333**							
	(0.0137)							
s-t interest	-0.0520***	0.0369***						
	(0.00624)	(0.00781)						
wage	-0.0547***	-0.0455***	-0.126***					
	(0.0118)	(0.00860)	(0.0187)					
crop	-0.0412***	0.0273***	-0.0179	0.166***				
	(0.0150)	(0.00797)	(0.0168)	(0.0323)				
livestock	-0.0193**	0.000735	-0.0505***	-0.0108	0.0167*			
	(0.00824)	(0.00508)	(0.00926)	(0.0111)	(0.00969)			
l-t interest	-0.0249***	0.0122***	-0.00269	-0.0198***	-0.00176	0.0176***		
	(0.00523)	(0.00312)	(0.00588)	(0.00744)	(0.00406)	(0.00359)		
land	0.00789**	-0.00323	0.0152***	0.00316	-0.00103	-0.00487***	-0.0132***	
	(0.00310)	(0.00330)	(0.00407)	(0.00326)	(0.00245)	(0.00145)	(0.00394)	
machinery	0.0802***	0.0716***	0.130***	-0.106***	0.0289***	0.0146**	-0.00862*	0.0423*
	(0.0127)	(0.00999)	(0.0154)	(0.0196)	(0.0103)	(0.00613)	(0.00523)	(0.0252)
Output Quantity								
crops	-0.0320***	0.0296**	-0.0310**	0.0616***	-0.00979	-0.000156	0.0275**	0.0349*
	(0.0112)	(0.0120)	(0.0152)	(0.0124)	(0.00904)	(0.00565)	(0.0138)	(0.0189)
livestock	0.0543***	-0.0243	-0.00757	-0.0227	-0.0319**	0.0177**	-0.0767***	0.00171
	(0.0188)	(0.0228)	(0.0270)	(0.0193)	(0.0149)	(0.00848)	(0.0237)	(0.0338)
Time	-0.00358***	-0.000490	-0.00312***	0.00162**	3.09e-05	2.28e-05	0.00218***	-0.000846
	(0.000534)	(0.000551)	(0.000739)	(0.000682)	(0.000409)	(0.000255)	(0.000648)	(0.000891)
Intercept	7.029***	0.889	6.856***	-3.555***	0.572	-0.302	-3.491***	1.369
	(0.977)	(0.977)	(1.347)	(1.265)	(0.744)	(0.466)	(1.156)	(1.603)
Observations	62	62	62	62	62	62	62	62
R-squared	0.923	0.259	0.799	0.914	0.846	0.885	0.497	0.793

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B.1 Regression Estimates for the Partial Static Model for Illinois

Independent Variables	Dependent Variables (Cost Shares) Feed	S-T credit	Labor	Crop
Input Price				
feed	-0.0170	-0.000529	0.00818	0.107***
	(0.0210)	(0.00831)	(0.0221)	(0.0220)
s-t interest	-0.000529	0.0241***	-0.00877	0.0368***
	(0.00831)	(0.00624)	(0.0120)	(0.0124)
wage	0.00818	-0.00877	-0.0235	0.108***
	(0.0221)	(0.0120)	(0.0432)	(0.0322)
crop	0.107***	0.0368***	0.108***	-0.219***
	(0.0220)	(0.0124)	(0.0322)	(0.0494)
other	-0.152***	-0.0343**	-0.0828*	-0.278***
	(0.0347)	(0.0167)	(0.0490)	(0.0411)
Quasi-Fixed				
livestock	0.0533***	-0.00392	0.0113	-0.0130
	(0.0166)	(0.00816)	(0.0247)	(0.0188)
l-t interest	-0.0148	0.0183***	-0.0306*	0.0496***
	(0.0113)	(0.00554)	(0.0170)	(0.0132)
land	-0.00105	-0.00470**	-0.0170***	0.00889*
	(0.00437)	(0.00208)	(0.00626)	(0.00490)
machinery	-0.0260	-0.0154	-0.0367	0.132***
	(0.0196)	(0.00996)	(0.0281)	(0.0300)
Output Quantity				
crops	-0.00415	-0.00337	-0.00334	-0.000277
	(0.00576)	(0.00281)	(0.00861)	(0.00657)
livestock	0.0241	0.0186**	0.0642**	0.0581***
	(0.0185)	(0.00907)	(0.0276)	(0.0209)
Time	-0.000298	0.000964***	0.00387***	-0.00103
	(0.000748)	(0.000374)	(0.00126)	(0.00106)
Intercept	0.580	-2.203***	-7.931***	1.560
	(1.420)	(0.714)	(2.419)	(2.041)
Observations	62	62	62	62
R-squared	0.915	0.871	0.341	0.876

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B.2 Regression Estimates for the Partial Static Model for Indiana

Independent Variables	Dependent Variables (Cost Shares) Feed	S-T credit	Labor	Crop
Input Price				
feed	-0.00822	-0.00601	-0.0510***	0.0538***
	(0.0166)	(0.00684)	(0.0169)	(0.0206)
s-t interest	-0.00601	0.0282***	0.00571	0.0237*
	(0.00684)	(0.00558)	(0.0104)	(0.0124)
wage	-0.0510***	0.00571	0.0396	0.175***
	(0.0169)	(0.0104)	(0.0332)	(0.0315)
crop	0.0538***	0.0237*	0.175***	-0.259***
	(0.0206)	(0.0124)	(0.0315)	(0.0501)
other	0.000895	-0.0310**	-0.186***	-0.342***
	(0.0252)	(0.0138)	(0.0361)	(0.0389)
Quasi-Fixed				
livestock	0.0167	0.00227	0.0608***	-0.00350
	(0.0119)	(0.00672)	(0.0179)	(0.0180)
l-t interest	0.000771	0.0268***	-0.0132	0.0200
	(0.00912)	(0.00492)	(0.0138)	(0.0142)
land	0.000321	-0.00455**	-0.0186***	0.0142***
	(0.00340)	(0.00186)	(0.00492)	(0.00512)
machinery	-0.0126	-0.0189**	-0.0790***	0.172***
	(0.0158)	(0.00931)	(0.0235)	(0.0313)
Output Quantity				
crops	-0.0302***	-0.00117	0.00422	0.0362**
	(0.0114)	(0.00632)	(0.0171)	(0.0176)
livestock	0.0215	-0.00196	0.0136	0.121***
	(0.0176)	(0.00994)	(0.0270)	(0.0267)
Time	0.000362	0.000453	0.00450***	-0.00407***
	(0.000754)	(0.000424)	(0.00124)	(0.00135)
Intercept	-0.523	-1.023	-8.718***	6.641**
	(1.429)	(0.811)	(2.390)	(2.585)
Observations	62	62	62	62
R-squared	0.871	0.913	0.659	0.910

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B.3 Regression Estimates for the Partial Static Model for Iowa

Independent Variables	Dependent Variables (Cost Shares) Feed	S-T credit	Labor	Crop
Input Price				
feed	0.0336	-0.000552	-0.0758***	0.0760***
	(0.0221)	(0.00832)	(0.0197)	(0.0189)
s-t interest	-0.000552	0.0451***	0.00179	0.00725
	(0.00832)	(0.00641)	(0.0112)	(0.0118)
wage	-0.0758***	0.00179	0.0301	0.192***
	(0.0197)	(0.0112)	(0.0311)	(0.0265)
crop	0.0760***	0.00725	0.192***	-0.250***
	(0.0189)	(0.0118)	(0.0265)	(0.0437)
other	-0.343***	-0.00799	-0.0418	-0.150***
	(0.0355)	(0.0169)	(0.0381)	(0.0341)
Quasi-Fixed				
livestock	0.111***	-0.00272	0.0486**	-0.0902***
	(0.0186)	(0.00950)	(0.0213)	(0.0168)
l-t interest	0.0433***	0.0204***	-0.0141	-0.0102
	(0.0124)	(0.00601)	(0.0141)	(0.0116)
land	-0.00437	-0.00668**	-0.0182***	0.0133***
	(0.00546)	(0.00265)	(0.00607)	(0.00511)
machinery	-0.0325*	-0.00798	-0.0996***	0.193***
	(0.0196)	(0.0106)	(0.0236)	(0.0268)
Output Quantity				
crops	-0.0546***	-0.00395	0.0184	0.0140
	(0.0111)	(0.00556)	(0.0128)	(0.0108)
livestock	0.117***	0.00551	-0.0784***	0.102***
	(0.0238)	(0.0120)	(0.0271)	(0.0212)
Time	0.00649***	0.000273	0.00241*	-0.00788***
	(0.00104)	(0.000516)	(0.00128)	(0.00122)
Intercept	-13.05***	-0.809	-3.730	14.17***
	(1.889)	(0.947)	(2.359)	(2.294)
Observations	62	62	62	62
R-squared	0.931	0.890	0.323	0.899

Standard errors in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Appendix B.4 Regression Estimates for the Partial Static Model for Missouri

Independent Variables	Dependent Variables (Cost Shares) Feed	S-T credit	Labor	Crop
Input Price				
feed	-0.0316**	0.0111*	0.00438	0.114***
	(0.0141)	(0.00662)	(0.0134)	(0.0214)
s-t interest	0.0111*	0.0422***	0.0183***	0.0264**
	(0.00662)	(0.00517)	(0.00674)	(0.0111)
wage	-0.0167	0.0183***	-0.0409**	0.128***
	(0.0180)	(0.00674)	(0.0168)	(0.0204)
crop	0.114***	0.0264**	0.128***	-0.299***
	(0.0214)	(0.0111)	(0.0204)	(0.0465)
other	-0.125***	-0.0334**	-0.153***	-0.223***
	(0.0216)	(0.0154)	(0.0241)	(0.0421)
Quasi-Fixed				
livestock	0.0950***	0.00115	0.0267**	-0.0450**
	(0.00963)	(0.00712)	(0.0107)	(0.0188)
l-t interest	-0.0281***	0.0160***	0.00672	0.0575***
	(0.00724)	(0.00522)	(0.00799)	(0.0134)
land	0.00420	-0.0104***	-0.0206***	0.000817
	(0.00270)	(0.00192)	(0.00303)	(0.00517)
machinery	-0.0191	-0.0151	-0.0717***	0.155***
	(0.0153)	(0.00944)	(0.0154)	(0.0305)
Output Quantity				
crops	-0.00840	0.0102	0.0586**	-0.0540
	(0.0239)	(0.0173)	(0.0265)	(0.0457)
livestock	-0.0910	0.0730*	-0.0931	-0.316***
	(0.0633)	(0.0440)	(0.0696)	(0.118)
Time	0.000835	-0.000915	0.00720***	0.00580***
	(0.00131)	(0.000816)	(0.00137)	(0.00220)
Intercept	-1.124	1.197	-13.60***	-9.447**
	(2.292)	(1.407)	(2.372)	(3.790)
Observations	62	62	62	62
R-squared	0.940	0.904	0.830	0.862

Standard errors in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Appendix B.5 Regression Estimates for the Partial Static Model for Ohio

Independent Variables	Dependent Variables (Cost Shares) Feed	S-T credit	Labor	Crop
Input Price				
feed	0.0198	0.000331	-0.112***	0.0434*
	(0.0154)	(0.00615)	(0.0144)	(0.0243)
s-t interest	0.000331	0.0323***	-0.00623	0.0407***
	(0.00615)	(0.00491)	(0.00888)	(0.0130)
wage	-0.112***	-0.00623	0.0111	0.208***
	(0.0144)	(0.00888)	(0.0287)	(0.0304)
crop	0.0434*	0.0407***	0.208***	-0.373***
	(0.0243)	(0.0130)	(0.0304)	(0.0640)
other	0.0255	-0.0349***	-0.121***	-0.284***
	(0.0218)	(0.0132)	(0.0356)	(0.0460)
Quasi-Fixed				
livestock	0.0178	0.00671	0.0326*	-0.00746
	(0.0109)	(0.00689)	(0.0189)	(0.0228)
l-t interest	0.0235***	0.0254***	-0.0164	-0.0128
	(0.00754)	(0.00461)	(0.0126)	(0.0155)
land	-0.00814**	-0.00693***	-0.0221***	0.0211***
	(0.00357)	(0.00222)	(0.00599)	(0.00746)
machinery	-0.0107	-0.0292***	-0.0892***	0.206***
	(0.0162)	(0.00929)	(0.0235)	(0.0390)
Output Quantity				
crops	-0.0342***	-0.00309	0.0745***	0.0846***
	(0.0106)	(0.00637)	(0.0174)	(0.0213)
livestock	-0.0418**	-0.0105	-0.0216	0.183***
	(0.0186)	(0.0118)	(0.0329)	(0.0391)
Time	0.00281***	0.00112***	0.00330***	-0.00745***
	(0.000551)	(0.000333)	(0.000914)	(0.00127)
Intercept	-4.525***	-2.198***	-6.608***	11.96***
	(1.041)	(0.629)	(1.761)	(2.384)
Observations	62	62	62	62
R-squared	0.886	0.878	0.647	0.878

Standard errors in parentheses
*** p<0.01, ** p<0.05, *
p<0.1

Appendix C.1 Regression Estimates for Dynamic Model for Illinois

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0337							
	(0.0310)							
s-t interest	-0.0785	-0.0785						
	(0.0483)	(0.0483)						
wage	0.958***	0.0348	-0.0330					
	(0.0157)	(0.0590)	(0.0260)					
crop	-0.346***	-0.0609	0.256***	0.154**				
	(0.0653)	(0.0409)	(0.0639)	(0.0598)				
livestock	-0.0884	0.00622	0.0239	-0.111*	0.325***			
	(0.0546)	(0.0353)	(0.0516)	(0.0675)	(0.0744)			
l-t interest	0.0522	0.279***	-0.0411	-0.0158	-0.0367	-0.00575		
	(0.0325)	(0.0733)	(0.0375)	(0.0324)	(0.0254)	(0.0195)		
land	-0.102**	0.00208	0.0544	-0.153***	0.0787*	-0.0183	0.454***	
	(0.0440)	(0.0227)	(0.0382)	(0.0493)	(0.0437)	(0.0174)	(0.0862)	
machinery	0.106***	0.0467***	-0.111***	0.0670**	0.0336	-0.0455***	-0.0117	0.154***
	(0.0297)	(0.0169)	(0.0288)	(0.0298)	(0.0265)	(0.0103)	(0.0464)	(0.0459)
Output Quantity								
crops	0.0166*	0.00395	-0.0171**	-0.00496	0.00444	-0.00859**	0.0212	-0.0135
	(0.00935)	(0.00439)	(0.00783)	(0.0101)	(0.00887)	(0.00377)	(0.0186)	(0.0156)
livestock	0.00145	0.000797	-0.00193	0.00760*	-0.00226	0.00211	-0.00268	0.00671
	(0.00353)	(0.00153)	(0.00292)	(0.00391)	(0.00329)	(0.00129)	(0.00754)	(0.00627)
Time	-0.000262	-0.000141*	0.000181	0.000426	0.000149	-0.000125*	0.000820**	-0.000380
	(0.000182)	(8.12e-05)	(0.000149)	(0.000355)	(0.000168)	(6.89e-05)	(0.000372)	(0.000295)
Intercept	0.266	0.224	-0.0995	-0.870	-0.308	0.329**	-1.826***	0.875
	(0.365)	(0.173)	(0.304)	(0.715)	(0.337)	(0.147)	(0.700)	(0.543)
Observations	61	61	61	61	61	61	61	61
R-squared	0.874	0.080	0.852	0.306	0.397	0.474	0.323	0.235

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C.2 Regression Estimates for Dynamic Model for Indiana

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0625							
	(0.0760)							
s-t interest	-0.0823**	-0.0823**						
	(0.0359)	(0.0359)						
wage	0.730***	-0.0423	-0.0171					
	(0.0504)	(0.0331)	(0.0939)					
crop	-0.190***	0.00438	-0.0856	0.343***				
	(0.0709)	(0.0426)	(0.0687)	(0.0664)				
livestock	-0.0854	0.0523	0.216***	-0.0399	0.481***			
	(0.0648)	(0.0466)	(0.0613)	(0.0676)	(0.0912)			
l-t interest	0.205***	0.622***	-0.0833**	0.113***	0.0507	-0.0358		
	(0.0396)	(0.0870)	(0.0378)	(0.0389)	(0.0403)	(0.0358)		
land	-0.126**	-0.00896	-0.113*	-0.223***	0.0695*	0.0486*	0.326***	
	(0.0562)	(0.0216)	(0.0667)	(0.0464)	(0.0404)	(0.0254)	(0.0772)	
machinery	0.0168	0.0656***	-0.0435	0.00222	-0.0275	-0.0340**	-0.0580	0.203***
	(0.0341)	(0.0177)	(0.0545)	(0.0266)	(0.0199)	(0.0133)	(0.0368)	(0.0409)
Output Quantity								
crops	0.0586***	0.00201	-0.0324*	-0.0186	0.00985	-0.0136**	-0.00194	-0.0273
	(0.0152)	(0.00494)	(0.0173)	(0.0123)	(0.00959)	(0.00643)	(0.0191)	(0.0199)
livestock	-0.0104	0.000326	0.00706	0.0303***	-0.00383	0.00301	-0.00394	0.0153
	(0.00984)	(0.00344)	(0.0117)	(0.00780)	(0.00581)	(0.00410)	(0.0117)	(0.0126)
Time	-0.000719**	-8.64e-05	0.000135	0.000188	0.000161	0.000152	0.000840**	-0.000635
	(0.000353)	(0.000109)	(0.000394)	(0.000304)	(0.000204)	(0.000140)	(0.000423)	(0.000435)
Intercept	0.747	0.160	0.0674	-0.511	-0.403	-0.155	-1.562**	1.463*
	(0.653)	(0.186)	(0.705)	(0.552)	(0.355)	(0.242)	(0.750)	(0.782)
Observations	61	61	61	61	61	61	61	61
R-squared	0.700	0.476	0.639	0.505	0.507	0.275	0.385	0.312

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C.3 Regression Estimates for Dynamic Model for Iowa

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	-0.0190							
	(0.0357)							
s-t interest	-0.237***	-0.113						
	(0.0426)	(0.0909)						
wage	0.861***	0.131***	0.0947***					
	(0.0376)	(0.0374)	(0.0294)					
crop	-0.460***	-0.242***	0.354***	0.193***				
	(0.0705)	(0.0555)	(0.0633)	(0.0549)				
livestock	-0.152**	-0.148***	-0.0345	-0.218***	0.585***			
	(0.0598)	(0.0308)	(0.0602)	(0.0495)	(0.0708)			
l-t interest	0.168***	0.156*	-0.161***	-0.0186	-0.0558**	0.0729**		
	(0.0373)	(0.0818)	(0.0315)	(0.0446)	(0.0277)	(0.0315)		
land	-0.244***	-0.0744***	0.0800	-0.226***	0.0267	-0.00739	0.0840*	
	(0.0478)	(0.0280)	(0.0561)	(0.0494)	(0.0393)	(0.0280)	(0.0472)	
machinery	0.124***	0.0671***	-0.0892*	0.124***	-0.0383	-0.0891***	-0.0395	0.163***
	(0.0422)	(0.0245)	(0.0465)	(0.0321)	(0.0388)	(0.0196)	(0.0370)	(0.0544)
Output Quantity								
crops	0.0182	0.0127**	0.00750	-0.00458	0.00975	0.00233	-0.00742	-0.0244
	(0.0156)	(0.00617)	(0.0174)	(0.0111)	(0.0161)	(0.00711)	(0.0173)	(0.0200)
livestock	0.00440	0.00112	-0.0185**	0.0151**	-0.0183**	-0.000398	0.00740	0.0178*
	(0.00863)	(0.00337)	(0.00938)	(0.00632)	(0.00888)	(0.00384)	(0.00911)	(0.0107)
Time	-0.000780**	-0.000457***	0.000719*	-0.000313	0.000660*	4.08e-05	-0.000101	-0.000767*
	(0.000348)	(0.000131)	(0.000395)	(0.000245)	(0.000350)	(0.000155)	(0.000366)	(0.000448)
Intercept	1.193**	0.696***	-1.268*	0.474	-1.182**	-0.125	0.205	1.649**
	(0.602)	(0.223)	(0.671)	(0.427)	(0.598)	(0.261)	(0.620)	(0.759)
Observations	61	61	61	61	61	61	61	61
R-squared	0.655	0.227	0.699	0.435	0.716	-0.134	0.134	0.225

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C.4 Regression Estimates for Dynamic Model for Missouri

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.0778							
	(0.0504)							
s-t interest	-0.0942***	-0.451***						
	(0.0309)	(0.0694)						
wage	0.743***	-0.0998***	0.0500					
	(0.0477)	(0.0325)	(0.0603)					
crop	-0.316***	-0.111*	0.102*	0.234***				
	(0.0520)	(0.0582)	(0.0606)	(0.0570)				
livestock	0.0770	0.0491	-0.128**	-0.0946	0.583***			
	(0.0510)	(0.0450)	(0.0556)	(0.0661)	(0.0774)			
l-t interest	-0.0171	0.452***	0.0473**	-0.0490	-0.0706***	0.0214		
	(0.0208)	(0.0590)	(0.0227)	(0.0316)	(0.0249)	(0.0175)		
land	-0.183***	-0.105***	-0.153**	-0.287***	0.106**	-0.0223	0.251***	
	(0.0587)	(0.0354)	(0.0625)	(0.0598)	(0.0518)	(0.0233)	(0.0715)	
machinery	0.142***	0.102***	-0.0355	0.121***	-0.00561	-0.0209*	-0.0626*	0.110***
	(0.0395)	(0.0233)	(0.0432)	(0.0296)	(0.0282)	(0.0119)	(0.0367)	(0.0427)
Output Quantity								
crops	-0.0126	0.0143	-0.0527	-0.0325	0.0390	-0.00372	0.0785**	-0.140**
	(0.0586)	(0.0182)	(0.0583)	(0.0314)	(0.0296)	(0.0125)	(0.0386)	(0.0653)
livestock	-0.0406	0.0262***	0.0658**	-0.0153	0.000855	0.00768	0.0220	-0.00523
	(0.0303)	(0.00908)	(0.0305)	(0.0161)	(0.0149)	(0.00670)	(0.0185)	(0.0314)
Time	0.000612	-0.000616**	-0.000576	0.00108**	-0.000444	-0.000119	-0.00118*	0.00155
	(0.00101)	(0.000272)	(0.000943)	(0.000500)	(0.000479)	(0.000194)	(0.000622)	(0.00111)
Intercept	-0.955	1.069**	1.075	-1.906**	0.713	0.214	1.915*	-2.421
	(1.716)	(0.457)	(1.591)	(0.848)	(0.807)	(0.327)	(1.046)	(1.863)
Observations	61	61	61	61	61	61	61	61
R-squared	0.559	0.389	0.511	0.436	0.601	0.590	0.579	0.186

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix C.5 Regression Estimates for Dynamic Model for Ohio

Independent Variables	Dependent Variables (Cost Shares)							
	Feed	S-T credit	Labor	Crop	Livestock	L-T credit	Land	Machinery
Input Price								
feed	0.139***							
	(0.0470)							
s-t interest	0.0597	-0.723***						
	(0.0380)	(0.0962)						
wage	0.635***	-0.145***	-0.0386					
	(0.0507)	(0.0383)	(0.0864)					
crop	-0.123*	0.0103	-0.310***	0.203***				
	(0.0748)	(0.0356)	(0.0741)	(0.0649)				
livestock	-0.0883	0.0532	0.366***	-0.186***	0.251***			
	(0.0623)	(0.0485)	(0.0653)	(0.0576)	(0.0832)			
l-t interest	0.155***	0.689***	0.0418	0.147***	0.0541	-0.0621		
	(0.0385)	(0.0737)	(0.0394)	(0.0352)	(0.0414)	(0.0412)		
land	-0.108**	0.00534	-0.102*	-0.149***	-0.0165	0.0521**	0.207***	
	(0.0505)	(0.0191)	(0.0583)	(0.0535)	(0.0342)	(0.0219)	(0.0664)	
machinery	0.0201	0.0436***	-0.0130	-0.0231	0.0208	-0.00905	-0.0440	0.181***
	(0.0262)	(0.0142)	(0.0403)	(0.0273)	(0.0162)	(0.0120)	(0.0284)	(0.0404)
Output Quantity								
crops	0.0635***	-0.00266	-0.0293*	0.0176	0.0135	-0.0123**	-0.00266	0.00604
	(0.0135)	(0.00477)	(0.0161)	(0.0132)	(0.00859)	(0.00611)	(0.0152)	(0.0236)
livestock	-0.0191**	0.00268	0.0106	0.00723	-0.00441	0.00290	0.00982	0.00862
	(0.00748)	(0.00272)	(0.00835)	(0.00765)	(0.00471)	(0.00336)	(0.00866)	(0.0133)
Time	-0.000614**	-4.78e-05	0.000150	-4.93e-05	-8.73e-05	0.000117	-4.41e-05	-0.000959**
	(0.000263)	(9.09e-05)	(0.000306)	(0.000263)	(0.000161)	(0.000118)	(0.000304)	(0.000461)
Intercept	0.609	0.110	-0.0499	-0.240	0.0504	-0.0981	-0.00853	1.738**
	(0.440)	(0.142)	(0.504)	(0.459)	(0.266)	(0.190)	(0.515)	(0.778)
Observations	61	61	61	61	61	61	61	61
R-squared	0.767	0.409	0.747	0.538	0.748	0.148	0.315	0.260

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix D.1 Regression Estimates for Dynamic Adjustment Matrix for Illinois

	Adjustment Coefficients								
	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	-0.00269	-0.633***	-0.129	0.392***	-0.0543	0.265	0.0611	0
		(0.0290)	(0.157)	(0.0922)	(0.0798)	(0.0368)	(0.194)	(0.149)	
L-t Credit	0	0.0152**	-0.0815**	0.0380*	-0.00216	-0.00494	-0.0452	0.115***	0
		(0.00665)	(0.0360)	(0.0212)	(0.0183)	(0.00845)	(0.0445)	(0.0342)	
Land	0	0.00839	-0.0633	-0.124***	0.0350	0.0265**	0.213***	-0.118**	0
		(0.00968)	(0.0524)	(0.0308)	(0.0267)	(0.0123)	(0.0649)	(0.0498)	
Machinery	0	-0.00609	0.0515	0.0685***	-0.0189	-0.0212**	-0.152***	0.0965***	0
		(0.00720)	(0.0389)	(0.0229)	(0.0198)	(0.00915)	(0.0482)	(0.0371)	
Other	0	0	0	0	0	0	0	0	0

Appendix D.2 Regression Estimates for Dynamic Adjustment Matrix for Indiana

	Adjustment Coefficients								
	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	-0.00269	-0.633***	-0.129	0.392***	-0.0543	0.265	0.0611	0
		(0.0290)	(0.157)	(0.0922)	(0.0798)	(0.0368)	(0.194)	(0.149)	
L-t Credit	0	0.0152**	-0.0815**	0.0380*	-0.00216	-0.00494	-0.0452	0.115***	0
		(0.00665)	(0.0360)	(0.0212)	(0.0183)	(0.00845)	(0.0445)	(0.0342)	
Land	0	0.00839	-0.0633	-0.124***	0.0350	0.0265**	0.213***	-0.118**	0
		(0.00968)	(0.0524)	(0.0308)	(0.0267)	(0.0123)	(0.0649)	(0.0498)	
Machinery	0	-0.00609	0.0515	0.0685***	-0.0189	-0.0212**	-0.152***	0.0965***	0
		(0.00720)	(0.0389)	(0.0229)	(0.0198)	(0.00915)	(0.0482)	(0.0371)	
Other	0	0	0	0	0	0	0	0	0

Appendix D.3 Regression Estimates for Dynamic Adjustment Matrix for Iowa

Adjustment Coefficients

	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	-0.0704***	-0.348***	-0.228***	0.802***	-0.0646***	0.0386	-0.152	0
		(0.0237)	(0.122)	(0.0499)	(0.0707)	(0.0197)	(0.0767)	(0.0935)	
L-t Credit	0	0.00537	-0.0309	0.0466***	-0.0239	-0.0112*	-0.0450**	0.0619**	0
		(0.00688)	(0.0353)	(0.0145)	(0.0205)	(0.00571)	(0.0223)	(0.0271)	
Land	0	0.0216	-0.0121	-0.106***	0.0824*	0.0392***	0.120**	-0.140**	0
		(0.0146)	(0.0751)	(0.0308)	(0.0436)	(0.0121)	(0.0473)	(0.0576)	
Machinery	0	-0.00274	0.0136	0.0560**	-0.0568*	-0.0275***	-0.0749**	0.113**	0
		(0.0115)	(0.0592)	(0.0243)	(0.0344)	(0.00957)	(0.0373)	(0.0455)	
Other	0	0	0	0	0	0	0	0	0

Appendix D.4 Regression Estimates for Dynamic Adjustment Matrix for Missouri

Adjustment Coefficients

	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	0.0218	-0.248	-0.00465	0.561***	-0.0552	0.0386	-0.0802	0
		(0.0517)	(0.207)	(0.107)	(0.0858)	(0.0481)	(0.138)	(0.207)	
L-t Credit	0	0.0198	0.0105	0.0912**	-0.0756***	0.00208	-0.121**	0.0452	0
		(0.0177)	(0.0709)	(0.0365)	(0.0293)	(0.0165)	(0.0471)	(0.0709)	
Land	0	0.0241	-0.315***	-0.119**	0.140***	-0.00777	0.358***	0.144	0
		(0.0282)	(0.113)	(0.0583)	(0.0468)	(0.0263)	(0.0752)	(0.113)	
Machinery	0	-0.00785	0.0921***	0.0225	-0.0346***	0.000130	-0.0984***	-0.0360	0
		(0.00779)	(0.0312)	(0.0161)	(0.0129)	(0.00724)	(0.0207)	(0.0312)	
Other	0	0	0	0	0	0	0	0	0

Appendix D.5 Regression Estimates for Dynamic Adjustment Matrix for Ohio

Adjustment Coefficients

	Input (i)								
Input (i)	Feed	S-t Credit	Labor	Crop	Livestock	L-t Credit	Land	Machinery	Other
Feed	1	0	0	0	0	0	0	0	0
S-t Credit	0	1	0	0	0	0	0	0	0
Labor	0	0	1	0	0	0	0	0	0
Crop	0	0	0	1	0	0	0	0	0
Livestock	0	-0.0753**	1.094***	-0.655***	0.685***	0.0243	-0.305**	-0.931***	0
		(0.0337)	(0.164)	(0.132)	(0.0902)	(0.0433)	(0.138)	(0.204)	
L-t Credit	0	0.0343**	-0.0467	0.135**	0.0205	-0.00637	-0.126*	0.223**	0
		(0.0159)	(0.0773)	(0.0624)	(0.0425)	(0.0204)	(0.0649)	(0.0960)	
Land	0	-0.00165	-0.0667	-0.134**	-0.0149	0.0237	0.193***	-0.0319	0
		(0.0138)	(0.0671)	(0.0542)	(0.0369)	(0.0177)	(0.0563)	(0.0833)	
Machinery	0	-0.000406	0.0225	0.0298*	0.00660	-0.00786	-0.0550***	0.0138	0
		(0.00417)	(0.0203)	(0.0164)	(0.0112)	(0.00537)	(0.0170)	(0.0252)	
Other	0	0	0	0	0	0	0	0	0

Appendix E.1Static Model Price Elasticity Estimates for Illinois

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livestock	LT credit	Land	Machinery
Feed	-1.13	-1.64	-1.23	-0.35	0.23	-0.22	0.25	1.11
ST credit	-0.41	1.00	-1.18	0.47	0.62	0.39	0.16	3.50
Labor	-1.23	-1.18	-3.99	-0.25	0.69	-0.26	0.45	2.40
Crop	-0.35	0.08	-0.08	0.14	-0.01	0.00	0.27	-0.36
Livestock	0.53	0.40	0.86	-0.13	0.83	-0.48	0.23	0.64
LT credit	-0.72	0.31	-0.26	0.00	-0.56	-10.77	-0.07	1.44
Land	0.13	0.03	0.11	0.23	0.07	0.00	-0.86	0.25
Machinery	0.42	0.34	0.45	-0.17	0.12	0.18	0.20	-0.64

Appendix E.2 Static Model Price Elasticity Estimates for Indiana

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livestock	LT credit	Land	Machinery
Feed	-0.71	-1.66	-0.43	0.12	-0.06	-0.16	0.14	0.69
ST credit	-0.21	1.07	-0.77	0.55	-0.27	0.99	0.15	4.34
Labor	-0.43	-0.77	-4.71	0.21	-0.22	-0.29	0.42	2.62
Crop	0.12	0.08	0.07	-0.25	0.01	-0.09	0.18	-0.20
Livestock	-0.24	-0.13	-0.28	0.04	-0.27	-0.32	0.23	0.89
LT credit	-0.75	0.62	-0.29	-0.43	-0.38	0.34	-0.04	1.19
Land	0.17	0.04	0.17	0.23	0.08	0.00	-0.99	0.24
Machinery	0.41	0.35	0.53	-0.10	0.14	0.16	0.12	-0.64

Appendix E.3 Static Model Price Elasticity Estimates for Iowa

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livestock	LT credit	Land	Machinery
Feed	-0.49	-0.71	-0.49	-0.13	0.34	-0.17	0.15	0.50
ST credit	-0.13	0.48	-1.76	0.25	1.37	0.60	-0.18	1.31
Labor	-0.49	-1.76	-6.18	-1.51	1.55	-0.62	0.51	3.64
Crop	-0.13	0.08	-0.48	0.18	-0.08	0.09	0.25	-0.36
Livestock	0.46	0.36	0.40	-0.05	0.15	0.04	0.16	-0.34
LT credit	-1.03	0.66	-0.62	0.29	0.16	-13.25	-0.16	0.90
Land	0.17	-0.03	0.11	0.18	0.14	-0.02	-0.91	0.24
Machinery	0.42	0.21	0.56	-0.15	-0.19	0.14	0.18	-0.46

Appendix E.4 Static Model Price Elasticity Estimates for Missouri

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livestock	LT credit	Land	Machinery
Feed	-0.61	-0.99	-0.31	0.22	-0.01	-0.02	0.35	0.48
ST credit	-0.05	2.19	-0.58	1.33	0.35	1.90	-0.56	3.19
Labor	-0.31	-0.58	-3.58	-1.23	-0.07	-0.50	0.55	2.07
Crop	0.22	0.17	-0.47	0.20	0.07	0.08	0.08	-0.56
Livestock	-0.19	0.17	-0.13	0.19	1.59	-0.52	0.58	0.39
LT credit	-0.17	0.82	-0.50	0.28	-0.47	-7.98	-0.24	1.35
Land	0.18	-0.05	0.28	0.11	0.20	-0.07	-1.10	0.17
Machinery	0.33	0.19	0.39	-0.25	0.07	0.18	0.07	-0.51

Appendix E.5 Static Model Price Elasticity Estimates for Ohio

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livestock	LT credit	Land	Machinery
Feed	-0.61	-2.49	-0.30	-0.13	-0.10	-0.14	0.17	0.85
ST credit	-0.33	0.90	-0.63	1.55	0.08	0.66	-0.05	3.93
Labor	-0.30	-0.63	-2.75	-0.10	-0.70	-0.01	0.33	2.18
Crop	-0.13	0.22	-0.05	0.32	-0.04	-0.10	0.14	-0.44
Livestock	-0.60	0.06	-1.88	-0.26	-0.31	-0.03	0.07	1.41
LT credit	-0.68	0.44	-0.01	-0.50	-0.02	-8.61	-0.05	0.78
Land	0.23	0.00	0.22	0.19	0.03	-0.01	-1.01	0.21
Machinery	0.44	0.29	0.55	-0.22	0.14	0.09	0.08	-0.55

Appendix F.1 Static Model Allen Elasticity Estimates of Substitution for Illinois

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-13.79							
ST credit	-0.02	654.80						
Labor	-30.67	-39.22	-97.93					
Crop	-2.06	3.99	-1.77	2.97				
Livestock	7.18	13.74	20.96	-0.50	61.36			
LT credit	-6.61	17.28	-5.31	-0.73	-11.93	-10.77		
Land	1.25	0.77	2.29	1.34	1.15	-0.37	-4.40	
Machinery	4.69	17.51	9.79	-1.57	2.78	5.84	1.01	-2.72

Appendix F.2 Static Model Allen Elasticity Estimates of Substitution for Indiana

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-4.81							
ST credit	-0.01	243.98						
Labor	-9.36	-28.21	-100.88					
Crop	0.65	4.74	1.20	-0.95				
Livestock	-1.97	-5.17	-6.42	0.23	-4.20			
LT credit	-4.51	40.07	-5.32	-3.78	-8.11	0.34		
Land	1.04	1.19	3.14	1.39	1.72	-0.39	-7.93	
Machinery	2.72	21.67	10.16	-0.94	3.58	4.63	0.91	-2.60

Appendix F.3 Static Model Allen Elasticity Estimates of Substitution for Iowa

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-2.90							
ST credit	-0.01	311.21						
Labor	-17.31	-52.58	-215.19					
Crop	-1.39	2.47	-14.69	4.64				
Livestock	2.79	9.92	13.07	-0.58	2.54			
LT credit	-5.60	25.85	-18.51	3.18	1.18	-13.25		
Land	0.95	-1.19	3.21	1.58	0.98	-1.03	-5.80	
Machinery	2.44	6.22	17.61	-1.71	-1.83	4.34	1.14	-2.27

Appendix F.4 Static Model Allen Elasticity Estimates of Substitution for Missouri

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-3.37							
ST credit	0.00	5929.85						
Labor	-6.86	-20.51	-79.19					
Crop	1.64	16.86	-9.11	2.78				
Livestock	-1.18	5.68	-3.54	1.38	105.62			
LT credit	-0.85	81.49	-9.14	2.33	-11.06	-7.98		
Land	0.95	-13.95	5.14	0.73	5.60	-2.78	-12.04	
Machinery	1.77	19.39	7.48	-2.32	1.40	5.14	0.57	-1.92

Appendix F.5 Static Model Allen Elasticity Estimates of Substitution for Ohio

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-4.28							
ST credit	-0.01	166.63						
Labor	-4.84	-24.81	-42.17					
Crop	-0.85	14.52	-0.66	3.49				
Livestock	-4.60	2.10	-29.72	-1.43	-4.07			
LT credit	-4.34	26.54	-0.21	-4.07	-0.99	-8.61		
Land	1.50	-1.19	2.97	1.24	0.66	-0.68	-10.00	
Machinery	2.98	17.77	7.53	-1.83	5.10	2.78	0.68	-2.01

Appendix G.1 Partial Static Model Price Elasticity Estimates for Illinois

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-1.09	0.08	0.15	1.42
ST credit	0.03	0.13	-0.34	1.85
Labor	0.15	-0.34	-1.49	2.67
Crop	-1.57	1.85	0.84	-2.42

Appendix G.2 Partial Static Model Price Elasticity Estimates for Indiana

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-0.90	-0.15	-0.29	0.55
ST credit	-0.01	0.47	0.35	1.38
Labor	-0.29	0.35	-0.14	3.71
Crop	0.19	1.38	1.21	-2.53

Appendix G.3 Partial Static Model Price Elasticity Estimates for Iowa

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-0.62	0.16	-0.41	0.58
ST credit	0.03	0.46	0.10	0.35
Labor	-0.41	0.10	0.02	6.39
Crop	-1.94	0.35	2.05	-3.49

Appendix G.4 Partial Static Model Price Elasticity Estimates for Missouri

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-0.98	1.00	0.08	0.77
ST credit	0.10	2.12	1.39	2.06
Labor	-0.03	1.39	-1.79	2.80
Crop	-0.55	2.06	1.09	-3.27

Appendix G.5 Partial Static Model Price Elasticity Estimates for Ohio

	PRICE ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-0.71	0.17	-0.70	0.47
ST credit	0.03	0.67	-0.24	2.23
Labor	-0.70	-0.24	-0.76	3.19
Crop	0.34	2.23	1.52	-3.43

Appendix H.1 Partial Static Model Allen Elasticity of Substitution Estimates for Illinois

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-13.20			
ST credit	0.79	345.65		
Labor	3.33	-5.69	-35.54	
Crop	-9.19	0.04	0.06	-21.79

Appendix H.2 Partial Static Model Allen Elasticity of Substitution Estimates for Indiana

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-6.22			
ST credit	-0.68	156.77		
Labor	-6.28	5.20	-1.87	
Crop	1.04	0.03	0.10	-19.45

Appendix H.3 Partial Static Model Allen Elasticity of Substitution Estimates for Iowa

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-3.73			
ST credit	0.90	307.46		
Labor	-14.60	2.74	2.90	
Crop	-18.78	0.01	0.11	-44.35

Appendix H.4 Partial Static Model Allen Elasticity of Substitution Estimates for Missouri

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-5.54			
ST credit	4.38	5790.92		
Labor	-0.99	14.25	-38.93	
Crop	-4.21	0.03	0.08	-29.33

Appendix H.5 Partial Static Model Allen Elasticity of Substitution Estimates for Ohio

	ALLEN ELASTICITY (Eij)			
	Price (j)			
Input (i)	Feed	ST credit	Labor	Crop
Feed	-6.70			
ST credit	0.46	999.38		
Labor	-7.00	3.84	13.65	
Crop	-17.93	0.04	0.10	-55.87

Appendix K.1 Dynamic Model Long-Run Price Elasticity Estimates for Illinois

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.50	-3.46	11.11	-3.81	-0.95	0.64	-0.98	1.47
ST credit	-0.87	-16.28	0.84	-2.59	0.35	12.72	0.29	2.37
Labor	11.11	0.84	-1.71	6.08	0.62	-1.43	1.45	-2.31
Crop	-3.81	-0.41	1.92	0.30	-0.74	-0.07	-0.92	0.74
Livestock	-2.52	0.22	0.76	-3.12	8.72	-1.05	2.54	1.25
LT credit	1.99	10.08	-1.43	-0.39	-1.26	-46.43	-0.46	-1.39
Land	-0.41	0.04	0.33	-0.60	0.47	-0.05	1.52	0.19
Machinery	0.56	0.23	-0.41	0.46	0.21	-0.15	0.15	-0.10

Appendix K.2 Dynamic Model Long-Run Price Elasticity Estimates for Indiana

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.41	-4.03	5.03	-1.11	-0.53	1.44	-0.72	0.38
ST credit	-0.53	-38.41	-0.82	0.40	2.71	31.69	-0.32	3.60
Labor	5.03	-0.82	-1.28	-1.55	4.40	-2.54	-2.14	-0.61
Crop	-1.11	0.06	-0.50	1.44	-0.21	0.79	-1.33	0.28
Livestock	-2.09	1.41	5.75	-0.87	11.72	1.38	1.97	-0.46
LT credit	6.57	19.47	-2.54	3.71	1.63	-78.90	1.65	-0.80
Land	-0.83	-0.04	-0.83	-1.57	0.59	0.42	1.69	-0.19
Machinery	0.23	0.30	-0.11	0.19	-0.06	-0.09	-0.10	0.08

Appendix K.3 Dynamic Model Long-Run Price Elasticity Estimates for Iowa

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.94	-7.31	5.23	-2.65	-0.78	1.05	-1.31	0.96
ST credit	-1.39	-4.53	4.31	-7.52	-4.53	4.96	-2.19	2.33
Labor	5.23	4.31	2.13	11.67	-0.99	-5.59	2.77	-2.70
Crop	-2.65	-2.49	3.74	1.14	-2.14	-0.16	-2.20	1.51
Livestock	-1.09	-1.20	-0.25	-1.70	4.03	-0.43	0.38	-0.11
LT credit	6.06	5.50	-5.59	-0.53	-1.81	81.52	-0.10	-2.91
Land	-1.37	-0.44	0.55	-1.31	0.31	-0.01	-0.31	-0.04
Machinery	0.79	0.37	-0.40	0.74	-0.05	-0.40	-0.04	0.02

Appendix K.4 Dynamic Model Long-Run Price Elasticity Estimates for Missouri

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.38	-6.68	4.16	-1.60	0.48	-0.05	-0.90	1.06
ST credit	-0.48	-33.84	-2.04	-7.95	3.63	33.00	-7.55	7.71
Labor	4.16	-2.04	0.10	2.26	-2.61	1.51	-3.07	-0.46
Crop	-1.60	-0.85	0.88	1.03	-0.71	-0.35	-2.21	1.25
Livestock	2.71	1.65	-4.13	-2.95	18.12	-2.27	3.57	0.09
LT credit	-0.33	13.92	1.51	-1.36	-2.12	-1.70	-0.58	-0.37
Land	-1.70	-1.04	-1.52	-2.82	1.15	-0.19	1.70	-0.37
Machinery	0.73	0.43	-0.08	0.60	0.03	-0.04	-0.13	-0.31

Appendix K.5 Dynamic Model Long-Run Price Elasticity Estimates for Ohio

Input (i)	*PRICE ELASTICITY (Eij)*							
	Price (j)							
	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	0.12	3.18	4.52	-0.70	-0.58	1.12	-0.64	0.43
ST credit	0.45	-37.66	-2.08	0.69	2.74	35.00	0.38	2.51
Labor	4.52	-2.08	-1.48	-4.34	5.36	1.48	-1.37	0.10
Crop	-0.70	0.10	-2.07	0.57	-1.25	1.06	-0.92	0.13
Livestock	-3.27	2.09	14.29	-7.06	8.78	2.14	-0.53	1.10
LT credit	5.35	23.14	1.48	5.09	1.85	-116.98	1.86	-0.01
Land	-0.88	0.08	-0.90	-1.27	-0.12	0.54	1.10	-0.13
Machinery	0.23	0.19	0.03	0.08	0.11	0.00	-0.05	-0.05

Appendix L.1 Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for Illinois

Input (i)	*ALLEN ELASTICITY (Eij)*							
	Price (j)							
	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-5.29							
ST credit	-0.03	-5499.09						
Labor	-97.73	27.56	-41.01					
Crop	-22.19	-27.68	38.78	4.60				
Livestock	-37.72	7.44	18.60	-14.85	464.04			
LT credit	18.26	600.07	-28.89	-4.52	-26.11	-46.43		
Land	-5.02	1.50	7.38	-4.72	13.11	-2.32	8.04	
Machinery	6.25	11.78	-9.46	3.08	5.56	-5.67	0.75	-0.30

Appendix L.2 Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for Indiana

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-2.66							
ST credit	-0.02	-5443.30						
Labor	-26.14	-30.12	-26.64					
Crop	-6.62	3.25	-9.28	12.77				
Livestock	-15.67	53.23	123.27	-4.80	367.50			
LT credit	39.55	1300.50	-46.43	28.58	34.71	-78.90		
Land	-5.52	-3.41	-16.31	-11.47	14.88	13.30	14.64	
Machinery	1.46	17.93	-2.40	1.06	-1.97	-3.17	-0.88	0.51

Appendix L.3 Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for Iowa

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-5.76							
ST credit	-0.06	-877.52						
Labor	-93.64	128.38	77.01					
Crop	-25.53	-86.96	112.33	17.49				
Livestock	-7.13	-32.86	-8.66	-15.63	40.51			
LT credit	33.05	217.55	-166.09	-7.51	-13.02	81.52		
Land	-8.27	-14.21	17.65	-14.09	2.40	-0.65	-1.90	
Machinery	4.70	11.07	-13.11	7.16	-0.64	-14.01	-0.24	0.24

Appendix L.4 Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for Missouri

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-2.01							
ST credit	-0.02	-62729.21						
Labor	-36.63	-71.28	3.58					
Crop	-12.18	-107.02	16.61	10.38				
Livestock	15.49	57.36	-99.60	-20.96	998.64			
LT credit	-1.68	1433.37	27.35	-13.13	-48.79	-1.70		
Land	-8.94	-171.11	-28.72	-25.98	34.88	-6.53	24.50	
Machinery	3.93	47.91	-1.67	4.86	0.35	-1.48	-1.74	-1.10

Appendix L.5 Dynamic Model Long-Run Allen Elasticity of Substitution Estimates for Ohio

	ALLEN ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	1.16							
ST credit	0.01	-4289.44						
Labor	-12.14	-81.24	-22.31					
Crop	-4.52	6.10	-27.74	5.60				
Livestock	-24.61	80.58	223.61	-40.83	469.31			
LT credit	34.23	1443.44	19.79	38.63	62.29	-116.98		
Land	-5.83	4.63	-12.24	-10.31	-4.51	19.01	13.37	
Machinery	1.50	11.21	0.35	0.38	3.95	-0.10	-0.64	-0.03

Appendix I.1 Dynamic Model Short-Run Price Elasticity Estimates for Illinois

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-1.01	-0.09	-0.20	0.01	-0.29	-0.37	0.04	0.05
ST credit	0.02	-1.01	0.01	0.03	0.00	0.00	0.03	0.03
Labor	-0.11	-0.07	-1.28	-0.05	-0.38	-0.47	-0.04	-0.01
Crop	0.22	0.32	0.25	-0.80	0.27	0.29	0.20	0.19
Livestock	0.10	0.19	0.13	0.08	-0.86	0.16	0.08	0.08
LT credit	0.04	0.04	0.00	0.04	0.04	-0.96	0.04	0.04
Land	0.19	0.17	0.18	0.19	0.18	0.17	-0.80	0.20
Machinery	0.25	0.24	0.24	0.25	0.24	0.24	0.25	-0.75

Appendix I.2 Dynamic Model Short-Run Price Elasticity Estimates for Indiana

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.88	-0.05	0.02	0.11	-0.02	-0.06	0.11	0.13
ST credit	0.03	-1.02	0.01	0.03	0.00	0.00	0.02	0.03
Labor	0.01	-0.04	-1.08	0.01	-0.13	-0.16	-0.02	0.03
Crop	0.20	0.35	0.25	-0.80	0.27	0.29	0.21	0.19
Livestock	0.06	0.11	0.07	0.06	-0.92	0.09	0.06	0.05
LT credit	0.04	0.05	0.00	0.04	0.05	-0.95	0.04	0.04
Land	0.13	0.08	0.11	0.13	0.11	0.10	-0.87	0.13
Machinery	0.27	0.29	0.27	0.27	0.28	0.28	0.27	-0.73

Appendix I.3 Dynamic Model Short-Run Price Elasticity Estimates for Iowa

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.87	-0.03	-0.16	0.07	0.09	-0.19	0.11	0.12
ST credit	0.03	-0.99	0.01	0.03	0.03	0.01	0.03	0.03
Labor	-0.05	-0.02	-1.46	-0.12	-0.09	-0.50	-0.06	-0.03
Crop	0.13	0.18	0.19	-0.86	0.14	0.19	0.13	0.13
Livestock	0.19	0.40	0.41	0.23	-0.79	0.43	0.19	0.18
LT credit	0.04	0.03	0.00	0.04	0.04	-0.97	0.04	0.04
Land	0.16	0.16	0.16	0.16	0.16	0.16	-0.84	0.16
Machinery	0.21	0.22	0.22	0.21	0.21	0.23	0.21	-0.79

Appendix I.4 Dynamic Model Short-Run Price Elasticity Estimates for Missouri

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.84	-0.05	0.10	0.15	0.04	0.05	0.14	0.17
ST credit	0.04	-0.96	0.04	0.04	0.04	0.04	0.04	0.04
Labor	0.01	-0.10	-1.11	-0.01	-0.21	-0.19	-0.05	0.03
Crop	0.14	0.19	0.15	-0.85	0.16	0.16	0.15	0.14
Livestock	0.09	0.49	0.18	0.10	-0.75	0.24	0.11	0.07
LT credit	0.05	0.15	0.03	0.06	0.09	-0.91	0.06	0.05
Land	0.10	0.00	0.08	0.09	0.06	0.06	-0.91	0.10
Machinery	0.28	0.27	0.28	0.28	0.27	0.27	0.28	-0.72

Appendix I.5 Dynamic Model Short-Run Price Elasticity Estimates for Ohio

	PRICE ELASTICITY (Eij)							
	Price (j)							
Input (i)	Feed	ST credit	Labor	Crop	Livest	LT credit	Land	Mach
Feed	-0.87	-0.03	0.08	0.12	-0.06	-0.03	0.10	0.13
ST credit	0.02	-1.04	0.01	0.02	-0.03	-0.02	0.02	0.02
Labor	0.04	-0.02	-0.99	0.04	-0.11	-0.09	-0.02	0.06
Crop	0.20	0.45	0.25	-0.80	0.38	0.35	0.22	0.18
Livestock	0.03	-0.02	0.02	0.03	-1.01	0.00	0.03	0.03
LT credit	0.04	0.03	0.00	0.04	0.03	-0.96	0.04	0.04
Land	0.11	0.08	0.10	0.11	0.09	0.09	-0.89	0.11
Machinery	0.30	0.38	0.32	0.30	0.36	0.35	0.31	-0.70

Appendix M.1 Regression Estimates the changes in relative lending for all years

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	5.98e-05	0.000251*	3.16e-06	-1.71e-06
	(9.23e-05)	(0.000144)	(9.06e-05)	(0.000132)
GDP	-0.727	0.442	0.523	0.427
	(0.666)	(1.037)	(0.654)	(0.954)
Interest	-0.650	-0.424	-0.436	-0.226
	(0.402)	(0.627)	(0.395)	(0.576)
Population	-6.63e-05	-0.00189**	-0.000726	-0.000781
	(0.000501)	(0.000780)	(0.000492)	(0.000718)
Failures	0.000635	-0.00898***	0.00122	-0.00191
	(0.00144)	(0.00225)	(0.00142)	(0.00207)
Number of Farms	0.00189	0.0219***	0.00940**	0.00941
	(0.00467)	(0.00727)	(0.00459)	(0.00669)
ST interest elasticity	-1.371	-32.08**	-32.84***	-15.81
	(8.401)	(13.08)	(8.248)	(12.03)
LT interest elasticity	-568.2***	-1,085***	-525.1***	-729.8***
	(112.8)	(175.6)	(110.7)	(161.5)
Land elasticity	32.63	-225.4***	40.61	-80.50
	(42.60)	(66.32)	(41.82)	(61.00)
Constant	512.9***	1,201***	466.0***	759.6***
	(113.3)	(176.4)	(111.2)	(162.2)
Observations	73	73	73	73
R-squared	0.642	0.553	0.630	0.534

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix M.2 Regression Estimates the changes in relative lending before 1970

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	0.00271**	-0.00543***	2.77e-05	-0.00129
	(0.00125)	(0.00170)	(0.00130)	(0.00101)
GDP	28.00***	4.432	29.29***	11.56
	(9.478)	(12.88)	(9.819)	(7.608)
Interest	1.929	-5.520	-11.68***	0.297
	(3.518)	(4.780)	(3.645)	(2.824)
Population	-0.000267	-0.00392**	-8.94e-05	-0.000307
	(0.00117)	(0.00159)	(0.00121)	(0.000938)
Failures	0.00794	-0.0187**	0.0133*	-0.0143***
	(0.00686)	(0.00932)	(0.00711)	(0.00551)
Number of Farms	0.0161	0.0544***	0.0208	0.0121
	(0.0134)	(0.0182)	(0.0139)	(0.0108)
ST interest elasticity	85.64***	-142.9***	-41.46*	6.176
	(24.32)	(33.05)	(25.20)	(19.52)
LT interest elasticity	3,116**	-6,162***	-2,227*	-622.3
	(1,262)	(1,715)	(1,307)	(1,013)
Land elasticity	127.6	38.66	51.72	0.661
	(92.83)	(126.1)	(96.17)	(74.52)
Constant	-3,425***	5,984***	2,011	526.6
	(1,259)	(1,711)	(1,304)	(1,011)
Observations	30	30	30	30
R-squared	0.768	0.771	0.488	0.661

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix M.3 Regression Estimates the changes in relative lending from 1970-1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	-0.000188	-6.35e-06	-0.000383**	0.000209
	(0.000165)	(0.000373)	(0.000189)	(0.000490)
GDP	-14.53**	-19.30	-29.66***	22.70
	(6.245)	(14.16)	(7.146)	(18.59)
Interest	-0.295	0.848	0.0276	1.060
	(0.325)	(0.736)	(0.371)	(0.966)
Population	-0.197**	0.190	-0.283***	0.0804
	(0.0790)	(0.179)	(0.0904)	(0.235)
Failures	0.00826**	0.00982	0.00726*	0.000964
	(0.00385)	(0.00873)	(0.00440)	(0.0115)
Number of Farms	0.257**	-0.340	0.324**	0.0953
	(0.125)	(0.283)	(0.143)	(0.371)
ST interest elasticity	939.9***	-381.3	1,303***	-1,014
	(315.5)	(715.3)	(361.1)	(939.2)
LT interest elasticity	-1,843***	454.5	-2,906***	655.0
	(482.1)	(1,093)	(551.8)	(1,435)
Land elasticity	-81.02	55.83	-30.93	-286.0
	(79.16)	(179.5)	(90.59)	(235.6)
Constant	652.7***	503.6	1,326***	105.4
	(194.5)	(441.0)	(222.6)	(579.0)
Observations	18	18	18	18
R-squared	0.951	0.583	0.956	0.771

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix M.4 Regression Estimates the changes in relative lending after 1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	9.37e-05	0.000102	5.90e-05	-0.000175*
	(0.000108)	(0.000187)	(8.16e-05)	(8.91e-05)
GDP	-5.546**	-1.772	1.297	0.508
	(2.520)	(4.364)	(1.902)	(2.078)
Interest	-0.633	-0.484	-1.695***	-0.732
	(0.754)	(1.305)	(0.569)	(0.622)
Population	0.0396	0.0501	-0.0332	0.0303
	(0.0437)	(0.0757)	(0.0330)	(0.0361)
Failures	0.00802*	0.00304	-0.00281	-0.00231
	(0.00469)	(0.00812)	(0.00354)	(0.00387)
Number of Farms	0.0661	0.0107	-0.0242	-0.0716*
	(0.0446)	(0.0772)	(0.0337)	(0.0368)
ST interest elasticity	-304.4	37.37	-298.3	908.1***
	(302.3)	(523.5)	(228.2)	(249.3)
LT interest elasticity	1,010	227.8	-342.8	-1,444**
	(691.1)	(1,197)	(521.6)	(569.9)
Land elasticity	-69.37	-416.6	23.61	-43.02
	(161.8)	(280.1)	(122.1)	(133.4)
Constant	-722.9	39.27	674.3	638.3
	(552.2)	(956.1)	(416.8)	(455.4)
Observations	25	25	25	25
R-squared	0.467	0.407	0.388	0.724

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix N.1 Regression Estimates for the value of lending for all years

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	245.6***	28.19***	84.90**	20.23
	(72.68)	(6.667)	(41.32)	(13.16)
GDP	4.382e+06***	-244,644***	2.747e+06***	-131,480
	(543,032)	(49,814)	(308,737)	(98,321)
Interest	923,946***	188,313***	519,538***	487,375***
	(329,942)	(30,267)	(187,586)	(59,739)
Population	-1,016**	65.76*	-452.1*	64.63
	(406.1)	(37.26)	(230.9)	(73.53)
Failures	7,585***	451.5***	2,720***	1,186***
	(1,155)	(105.9)	(656.6)	(209.1)
Number of Farms	11,720***	-1,083***	4,776**	-53.01
	(3,767)	(345.5)	(2,141)	(682.0)
ST interest elasticity	-1.713e+06	-1.523e+06***	3.277e+06	-4.650e+06***
	(6.352e+06)	(582,709)	(3.611e+06)	(1.150e+06)
LT interest elasticity	3.025e+08***	-9.562e+07***	2.846e+08***	-1.895e+08***
	(9.090e+07)	(8.339e+06)	(5.168e+07)	(1.646e+07)
Land elasticity	1.651e+08***	7.205e+06**	9.243e+07***	1.389e+07**
	(3.491e+07)	(3.202e+06)	(1.985e+07)	(6.320e+06)
Constant	-4.890e+08***	9.181e+07***	-3.832e+08***	1.735e+08***
	(9.105e+07)	(8.352e+06)	(5.176e+07)	(1.648e+07)
Observations	75	75	75	75
R-squared	0.945	0.970	0.938	0.960

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix N.2 Regression Estimates for the value of lending for before 1970

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	-29.71	-20.68	-14.31	0.838
	(26.23)	(17.08)	(29.03)	(3.527)
GDP	604,287***	164,032	273,683	198,965***
	(158,673)	(103,348)	(175,624)	(21,341)
Interest	243,615***	21,973	149,034*	-24,177**
	(76,918)	(50,098)	(85,135)	(10,345)
Population	89.41***	-26.46*	13.71	-5.040
	(23.54)	(15.33)	(26.05)	(3.166)
Failures	106.0	1.206	23.51	42.88***
	(90.15)	(58.72)	(99.78)	(12.12)
Number of Farms	-1,320***	-37.32	-715.0***	38.28
	(223.9)	(145.9)	(247.9)	(30.12)
ST interest elasticity	-298,663	-866,820**	-1.285e+06**	7,798
	(528,565)	(344,268)	(585,031)	(71,090)
LT interest elasticity	-1.182e+08***	-7.193e+07***	-1.176e+08***	-7.768e+06**
	(2.720e+07)	(1.771e+07)	(3.010e+07)	(3.658e+06)
Land elasticity	-2.032e+06	3.065e+06***	2.354e+06	566,482**
	(1.769e+06)	(1.152e+06)	(1.958e+06)	(237,951)
Constant	1.205e+08***	6.882e+07***	1.161e+08***	6.824e+06*
	(2.672e+07)	(1.740e+07)	(2.957e+07)	(3.594e+06)
Observations	31	31	31	31
R-squared	0.993	0.982	0.988	0.989

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix N.3 Regression Estimates for the value of lending for 1970-1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	-71.22*	44.01**	1.082	98.74***
	(38.64)	(19.94)	(39.04)	(28.69)
GDP	-4.773e+06***	1.586e+06**	229,738	4.148e+06***
	(1.465e+06)	(756,023)	(1.480e+06)	(1.088e+06)
Interest	463,699***	131,791***	242,744***	349,723***
	(76,142)	(39,302)	(76,946)	(56,534)
Population	-134,180***	-4,335	-78,604***	-35,956***
	(18,530)	(9,565)	(18,726)	(13,758)
Failures	2,340***	-37.90	-924.7	842.6
	(902.7)	(465.9)	(912.2)	(670.2)
Number of Farms	173,121***	12,996	109,114***	72,367***
	(29,239)	(15,092)	(29,548)	(21,709)
ST interest elasticity	-2.624e+08***	-8.000e+07**	-1.390e+08*	-1.051e+08*
	(7.400e+07)	(3.820e+07)	(7.478e+07)	(5.495e+07)
LT interest elasticity	-2.530e+08**	475,300	1.589e+07	-2.556e+07
	(1.131e+08)	(5.837e+07)	(1.143e+08)	(8.397e+07)
Land elasticity	-3.793e+07**	-9.929e+06	-2.303e+07	-2.584e+07*
	(1.857e+07)	(9.584e+06)	(1.876e+07)	(1.379e+07)
Constant	3.574e+08***	5.459e+07**	6.634e+06	5.007e+06
	(4.562e+07)	(2.355e+07)	(4.610e+07)	(3.387e+07)
Observations	18	18	18	18
R-squared	0.998	0.985	0.984	0.994

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix N.4 Regression Estimates for the value of lending for after 1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	120.3	5.797	20.38	-3.775
	(88.03)	(6.622)	(48.50)	(6.736)
GDP	6.210e+06***	-377,200***	4.546e+06***	-824,639***
	(1.893e+06)	(142,435)	(1.043e+06)	(144,875)
Interest	-1.346e+06**	43,735	-954,899***	87,408*
	(620,294)	(46,662)	(341,722)	(47,461)
Population	-53,715	711.6	-41,456**	3,198
	(35,287)	(2,654)	(19,440)	(2,700)
Failures	7,877**	968.5***	2,100	1,576***
	(3,896)	(293.1)	(2,147)	(298.1)
Number of Farms	-1,219	-2,417	-10,036	3,502
	(30,119)	(2,266)	(16,592)	(2,304)
ST interest elasticity	1.039e+08	2.178e+07	-4.275e+07	4.136e+07***
	(1.885e+08)	(1.418e+07)	(1.038e+08)	(1.442e+07)
LT interest elasticity	-4.201e+08	-7.013e+07*	-2.320e+08	-1.353e+08***
	(5.104e+08)	(3.839e+07)	(2.812e+08)	(3.905e+07)
Land elasticity	4.358e+07	-982,589	5.457e+07	3.754e+06
	(1.329e+08)	(9.999e+06)	(7.323e+07)	(1.017e+07)
Constant	2.751e+08	5.684e+07*	2.498e+08	8.668e+07**
	(4.495e+08)	(3.381e+07)	(2.476e+08)	(3.439e+07)
Observations	26	26	26	26
R-squared	0.956	0.959	0.959	0.986

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix O.1 Regression Estimates for the share of lending for all years

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	-2.33e-05	5.65e-05**	-8.48e-06	5.88e-05*
	(5.35e-05)	(2.50e-05)	(3.52e-05)	(3.15e-05)
GDP	0.271	-1.923***	1.277***	-0.886***
	(0.386)	(0.181)	(0.254)	(0.228)
Interest	0.856***	-0.107	0.0732	0.648***
	(0.233)	(0.109)	(0.153)	(0.138)
Population	6.82e-05	-0.000970***	-0.000643***	-2.86e-05
	(0.000287)	(0.000134)	(0.000189)	(0.000169)
Failures	0.00341***	-0.000251	0.000984*	0.00160***
	(0.000835)	(0.000391)	(0.000550)	(0.000493)
Number of Farms	-0.00137	0.00330***	0.00135	0.00186
	(0.00266)	(0.00125)	(0.00175)	(0.00157)
ST interest elasticity	12.24***	-4.223**	5.655*	-0.410
	(4.488)	(2.100)	(2.953)	(2.648)
LT interest elasticity	208.5***	-153.7***	399.6***	-376.8***
	(65.39)	(30.60)	(43.02)	(38.58)
Land elasticity	69.79***	19.29*	57.34***	1.855
	(24.69)	(11.55)	(16.24)	(14.57)
Constant	-224.6***	156.1***	-422.4***	361.6***
	(65.67)	(30.73)	(43.21)	(38.75)
Observations	74	74	74	74
R-squared	0.820	0.903	0.925	0.901

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix O.2 Regression Estimates for the share of lending before 1970

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	-0.000307	-8.83e-05	0.000125	2.30e-05
	(0.000423)	(0.000299)	(0.000161)	(0.000234)
GDP	8.991***	2.485	-2.525***	3.405**
	(2.557)	(1.809)	(0.975)	(1.419)
Interest	0.221	-1.732**	0.0624	-0.0929
	(1.239)	(0.877)	(0.473)	(0.688)
Population	0.00101***	-0.000749***	0.000459***	-0.000507**
	(0.000379)	(0.000268)	(0.000145)	(0.000210)
Failures	0.00126	-0.00116	-0.000315	0.00151*
	(0.00145)	(0.00103)	(0.000554)	(0.000806)
Number of Farms	-0.00645*	0.00314	-0.0111***	0.00819***
	(0.00361)	(0.00255)	(0.00138)	(0.00200)
ST interest elasticity	41.39***	-2.117	-1.673	5.977
	(8.516)	(6.026)	(3.247)	(4.726)
LT interest elasticity	901.6**	-281.3	-157.0	50.84
	(438.2)	(310.0)	(167.1)	(243.1)
Land elasticity	-46.37	108.9***	38.26***	38.95**
	(28.51)	(20.17)	(10.87)	(15.82)
Constant	-839.3*	194.6	188.7	-120.5
	(430.5)	(304.6)	(164.2)	(238.9)
Observations	31	31	31	31
R-squared	0.960	0.937	0.987	0.937

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix O.3 Regression Estimates for the share of lending from 1970-1987

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	-9.32e-05***	0.000121***	-4.15e-05	0.000237***
	(3.28e-05)	(4.10e-05)	(3.51e-05)	(4.97e-05)
GDP	-6.991***	4.895***	-4.212***	11.59***
	(1.242)	(1.553)	(1.331)	(1.886)
Interest	0.0237	0.158*	0.0600	0.402***
	(0.0646)	(0.0807)	(0.0692)	(0.0980)
Population	-0.145***	0.0541***	-0.0535***	-0.0694***
	(0.0157)	(0.0196)	(0.0168)	(0.0239)
Failures	0.000796	-0.00109	-0.00166**	0.00106
	(0.000766)	(0.000957)	(0.000821)	(0.00116)
Number of Farms	0.175***	-0.0449	0.0671**	0.151***
	(0.0248)	(0.0310)	(0.0266)	(0.0376)
ST interest elasticity	-4.156	-155.6**	83.17	-3.354
	(62.76)	(78.44)	(67.27)	(95.29)
LT interest elasticity	-310.4***	173.1	-157.6	-79.47
	(95.91)	(119.9)	(102.8)	(145.6)
Land elasticity	-37.41**	-2.647	-24.98	-59.63**
	(15.75)	(19.68)	(16.88)	(23.91)
Constant	233.2***	0.446	67.56	-192.7***
	(38.69)	(48.36)	(41.47)	(58.74)
Observations	18	18	18	18
R-squared	0.993	0.885	0.987	0.992

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix O.4 Regression Estimates for the share of lending after 1987

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	4.87e-05**	5.25e-06	6.42e-06	-7.71e-06
	(2.21e-05)	(8.69e-06)	(2.58e-05)	(1.08e-05)
GDP	-1.387***	-1.829***	2.766***	-2.210***
	(0.515)	(0.203)	(0.602)	(0.253)
Interest	-0.168	0.119**	-0.491***	0.235***
	(0.154)	(0.0606)	(0.180)	(0.0757)
Population	-0.0151*	-0.00210	-0.0218**	0.00668
	(0.00894)	(0.00352)	(0.0104)	(0.00439)
Failures	0.00219**	0.00114***	-2.83e-05	0.00290***
	(0.000959)	(0.000377)	(0.00112)	(0.000470)
Number of Farms	0.0449***	0.000925	0.00251	0.00954**
	(0.00912)	(0.00359)	(0.0106)	(0.00448)
ST interest elasticity	-75.82	55.69**	-61.35	105.4***
	(61.83)	(24.32)	(72.18)	(30.34)
LT interest elasticity	183.0	-128.3**	-32.36	-276.5***
	(141.3)	(55.59)	(165.0)	(69.36)
Land elasticity	24.99	-5.833	42.45	0.579
	(33.08)	(13.01)	(38.62)	(16.23)
Constant	-130.6	98.71**	71.29	161.7***
	(112.9)	(44.42)	(131.9)	(55.42)
Observations	25	25	25	25
R-squared	0.920	0.992	0.972	0.994

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix P.1 Regression Estimates for the change in lending for all years

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	-2.33e-05	5.65e-05**	-8.48e-06	5.88e-05*
	(5.35e-05)	(2.50e-05)	(3.52e-05)	(3.15e-05)
GDP	0.271	-1.923***	1.277***	-0.886***
	(0.386)	(0.181)	(0.254)	(0.228)
Interest	0.856***	-0.107	0.0732	0.648***
	(0.233)	(0.109)	(0.153)	(0.138)
Population	6.82e-05	-0.000970***	-0.000643***	-2.86e-05
	(0.000287)	(0.000134)	(0.000189)	(0.000169)
Failures	0.00341***	-0.000251	0.000984*	0.00160***
	(0.000835)	(0.000391)	(0.000550)	(0.000493)
Number of Farms	-0.00137	0.00330***	0.00135	0.00186
	(0.00266)	(0.00125)	(0.00175)	(0.00157)
ST interest elasticity	12.24***	-4.223**	5.655*	-0.410
	(4.488)	(2.100)	(2.953)	(2.648)
LT interest elasticity	208.5***	-153.7***	399.6***	-376.8***
	(65.39)	(30.60)	(43.02)	(38.58)
Land elasticity	69.79***	19.29*	57.34***	1.855
	(24.69)	(11.55)	(16.24)	(14.57)
Constant	-224.6***	156.1***	-422.4***	361.6***
	(65.67)	(30.73)	(43.21)	(38.75)
Observations	74	74	74	74
R-squared	0.820	0.903	0.925	0.901

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix P.2 Regression Estimates for the change in lending before 1970

	Dependent Variables			
Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	-0.000307	-8.83e-05	0.000125	2.30e-05
	(0.000423)	(0.000299)	(0.000161)	(0.000234)
GDP	8.991***	2.485	-2.525***	3.405**
	(2.557)	(1.809)	(0.975)	(1.419)
Interest	0.221	-1.732**	0.0624	-0.0929
	(1.239)	(0.877)	(0.473)	(0.688)
Population	0.00101***	-0.000749***	0.000459***	-0.000507**
	(0.000379)	(0.000268)	(0.000145)	(0.000210)
Failures	0.00126	-0.00116	-0.000315	0.00151*
	(0.00145)	(0.00103)	(0.000554)	(0.000806)
Number of Farms	-0.00645*	0.00314	-0.0111***	0.00819***
	(0.00361)	(0.00255)	(0.00138)	(0.00200)
ST interest elasticity	41.39***	-2.117	-1.673	5.977
	(8.516)	(6.026)	(3.247)	(4.726)
LT interest elasticity	901.6**	-281.3	-157.0	50.84
	(438.2)	(310.0)	(167.1)	(243.1)
Land elasticity	-46.37	108.9***	38.26***	38.95**
	(28.51)	(20.17)	(10.87)	(15.82)
Constant	-839.3*	194.6	188.7	-120.5
	(430.5)	(304.6)	(164.2)	(238.9)
Observations	31	31	31	31
R-squared	0.960	0.937	0.987	0.937

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix P.3 Regression Estimates for the change in lending from 1970-1987

Independent Variables	Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
	Dependent Variables			
Farm Income	-9.32e-05***	0.000121***	-4.15e-05	0.000237***
	(3.28e-05)	(4.10e-05)	(3.51e-05)	(4.97e-05)
GDP	-6.991***	4.895***	-4.212***	11.59***
	(1.242)	(1.553)	(1.331)	(1.886)
Interest	0.0237	0.158*	0.0600	0.402***
	(0.0646)	(0.0807)	(0.0692)	(0.0980)
Population	-0.145***	0.0541***	-0.0535***	-0.0694***
	(0.0157)	(0.0196)	(0.0168)	(0.0239)
Failures	0.000796	-0.00109	-0.00166**	0.00106
	(0.000766)	(0.000957)	(0.000821)	(0.00116)
Number of Farms	0.175***	-0.0449	0.0671**	0.151***
	(0.0248)	(0.0310)	(0.0266)	(0.0376)
ST interest elasticity	-4.156	-155.6**	83.17	-3.354
	(62.76)	(78.44)	(67.27)	(95.29)
LT interest elasticity	-310.4***	173.1	-157.6	-79.47
	(95.91)	(119.9)	(102.8)	(145.6)
Land elasticity	-37.41**	-2.647	-24.98	-59.63**
	(15.75)	(19.68)	(16.88)	(23.91)
Constant	233.2***	0.446	67.56	-192.7***
	(38.69)	(48.36)	(41.47)	(58.74)
Observations	18	18	18	18
R-squared	0.993	0.885	0.987	0.992

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix P.4 Regression Estimates for the change in lending after 1987

Independent Variables	*Dependent Variables* Debt in real estate FCS	Debt in real estate FSA	Debt in non-real estate FCS	Debt in non-real estate FSA
Farm Income	4.87e-05**	5.25e-06	6.42e-06	-7.71e-06
	(2.21e-05)	(8.69e-06)	(2.58e-05)	(1.08e-05)
GDP	-1.387***	-1.829***	2.766***	-2.210***
	(0.515)	(0.203)	(0.602)	(0.253)
Interest	-0.168	0.119**	-0.491***	0.235***
	(0.154)	(0.0606)	(0.180)	(0.0757)
Population	-0.0151*	-0.00210	-0.0218**	0.00668
	(0.00894)	(0.00352)	(0.0104)	(0.00439)
Failures	0.00219**	0.00114***	-2.83e-05	0.00290***
	(0.000959)	(0.000377)	(0.00112)	(0.000470)
Number of Farms	0.0449***	0.000925	0.00251	0.00954**
	(0.00912)	(0.00359)	(0.0106)	(0.00448)
ST interest elasticity	-75.82	55.69**	-61.35	105.4***
	(61.83)	(24.32)	(72.18)	(30.34)
LT interest elasticity	183.0	-128.3**	-32.36	-276.5***
	(141.3)	(55.59)	(165.0)	(69.36)
Land elasticity	24.99	-5.833	42.45	0.579
	(33.08)	(13.01)	(38.62)	(16.23)
Constant	-130.6	98.71**	71.29	161.7***
	(112.9)	(44.42)	(131.9)	(55.42)
Observations	25	25	25	25
R-squared	0.920	0.992	0.972	0.994

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1